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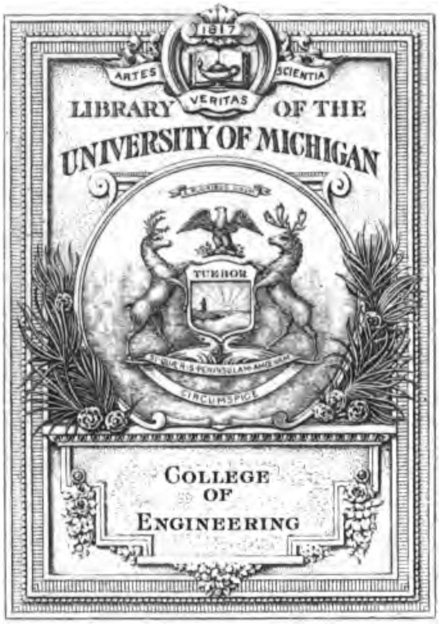

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DRAWING ROOM PRACTICE

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DRAWING ROOM PRACTICE

BY

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PREFACE

THIS book deals with the making of drawings, from the simplest constructions to complete assembly and working drawings of various classes. It is based upon experience gained in a number of the leading drawing offices and machine shops of this country and Europe and in class work in connection with the instruction of students, machinists and toolmakers interested in mechanical drawing.

It has been the observation of the author that young draftsmen and even many shop men of years of experience often find it difficult to visualize a piece of work yet to be completed in wood or metal, and in instructing such men in mechanical drawing it has been found desirable to put before them either a casting or forging representing the object to be drawn; or, where this is not feasible, as is ordinarily the case, to use photographic views which show to the eye the appearance of the work as it is to be when finished. The satisfactory results obtained under this method have led to the gathering of a wide variety of material in the way of photographic views of different classes of machine parts together with actual working drawings of such parts for use in specific chapters in this book.

This general plan of treatment has been discussed with many experienced draftsmen, instructors in mechanical drawing in trade schools, manual training schools and special evening classes, apprentice instructors, shop executives, toolmakers and machinists, and has received their approval and indorsement. It it believed, therefore, that the book will be of real service to all who are interested in the study and teaching of drawing and in the use of drawings in the shop. Moreover, there are certain chapters which should be of value to experienced draftsmen regularly engaged in the production of working drawings, these chapters dealing specifically with tool drawings and with limit dimensions on drawings used in manufacture.

The laying out of jigs and fixtures, punches and dies, and other special tools forms a most important part of the work of the modern drawing room and the draftsman wishing to develop in his profession must familiarize himself with approved methods of showing such tools on his drawings in order that they may be readily worked to in the shop and tool room. Systems of limits and tolerances for dimensions have already been adopted or are being adopted in the plants manufacturing parts in quantities, and here again many draftsmen, even of wide experience, must add to their knowledge by a study of methods of limit dimensions adapted to their own particular line of work. The chapters devoted to tool layouts and limit dimensions should be of benefit to many of the older draftsmen as well as to those of limited experience over the drawing board.

During the author's visits to various plants for the purpose of gathering photographic material, drawings and data, fullest co-operation and assistance have been extended by the management and by drawing room and shop executives. In this connection acknowledgment is especially made to the following firms:

B. C. Ames Company, Smith Premier Typewriter Company, Southern Pacific Company (Sacramento Shops), Holt Manufacturing Company, Savage Arms Company, Noiseless Typewriter Company, Keuffel & Esser Company, Theodore Alteneder & Sons.

THE AUTHOR.

CONTENTS

PREFACE v

CHAPTER PAGE

I. DRAWING INSTRUMENTS AND THEIR USES 1

Details of Equipment—Use of the T-Square and Triangle—Further Applications of the Triangle—Dividers and Compasses—Dividing the Circle—Suggestions for Practice—Application of the Curve—Exercise in Drawing Simple Lines and Circles—Simple Problems for the Drawing Board—To Bisect a Straight Line—To Erect a Perpendicular to a Line—To Divide a Line into Equal Parts—To Bisect an Angle—To Construct a Hexagon—To Find the Center of a Circle from Two Flat Sides—Triangular Figures—The Lines Used on Drawings—Lettering—Drawing Titles.

II. PROJECTION 26

Orthographic Projection—How Objects Appear to the Eye—Desirability of Two Views for Simple Details—The Planes of Projection—First-Angle Projection—Third-Angle Projection—The Glass Box Explanation—Projections of a Steel Square—Lines at an Angle to the Planes—Applications with True Lengths of Lines—Simple Auxiliary Views—Use of Sections in Projection—Several Views Often Necessary—The Use of Shade Lines—Section-Lining or Cross-Hatching.

III. PRACTICAL APPLICATIONS OF THE PRINCIPLES OF PROJECTION 54

Drawing a Bushing—A Bronze Bearing—Roller with Long Hub—A Spring Cap—Friction Parts—Shifting Lever—Other Machine Members—Sectional Views—Shaft Bearing Cap—Countershaft Box—Fly Wheel—Pipe Bracket—Engine and Compressor Parts—Valve Head Tool—Connecting Rod—Adjustable Planer Tool—Miscellaneous Examples—Different Arrangements of Punch and Die on Drawings.

IV. DEVELOPMENT OF SURFACES—INTERSECTIONS 82

Principles and Applications—Development of Cylinder Cut at an Angle—A Square Tube Developed—Hexagonal Figures—Elliptical Forms—Intersections of Cylinders at Right Angles—Cylinders at Other Angles—Sections of the Cone—The Ellipse—The Parabola—The Hyperbola—Intersections on Machine Parts—Connecting Rod Illustration.

CHAPTER PAGE

V. THE HELIX AND ITS APPLICATIONS 99

Angle, Pitch and Lead of Helix—Coil Springs—Common Methods of Showing Springs—The Screw Thread—Methods of Developing Thread Helix—Square Threads—Double Square Threads for Screws and Nuts—Square Thread Nut in Section—Quadruple Thread Screw—Tracing the Lead of a Single Thread on a Multiple Thread Screw—The Cutting of Square Threads—The Effect in Change in Position of Threading Tool—The Worm Thread—Methods of Showing Worm Threads—Spiral Milling Cutters—Drawing the Helix on Spiral Cutters—Taper Reamers with Spiral Teeth—The Helix on a Cone.

VI. SCREW THREADS IN THEIR CONVENTIONAL FORMS 116

Proportions of Standard Threads—Common Methods of Showing Threads—Appearance of Bolts in Place—Bolts and Nuts—Showing Tapped Holes—Blind Tapped Hole for Studs—Bolt, Nut and Screw Proportions—Hexagon and Square-Head Bolts and Nuts—Flat, Cup and Round Point Set Screws—Flat, Round and Oval Fillister Head Cap Screws—Machine Screws—Briggs Pipe Thread—Threaded Bushing—Spindle Nose and Face Plate Sections.

VII. SHOWING DETAIL PARTS—SECTIONS 123

Shafts, Spindles, Etc.—Slots and Key-Ways—Boring Bars and Cutters—Showing Keys in Shafts—Other Spindles and Shafts—Arbors and Trunnions—Bearings and Bushings—Bushings in Section—Pulleys and Couplings—Levers and Cams—Gears—Laying Out Spur Gears—Drawing of Spur Gear—Method of Striking Involute Curve—Hand Wheels and Handles—Hidden Sections or Dotted Sections—Other Machine Details—Showing Screw Heads—Pinned Joints—Knurled Bushings and Nuts—Various Tool Parts—Plug and Ring Gages—Milling Cutter Details.

VIII. PARTS AND SECTIONS IN ASSEMBLY DRAWINGS 142

Cross Sections for Metals—Methods of Cross Hatching—Cross Hatching Where Several Parts are in Contact—Cross Hatching of Spindle Boxes—Assembly Views—Two Speed Transmission—Universal Ball Vise—Section Through Milling Machine Spindle—Spindle and Cutter Assembly—Shaft Hanger—Cross Slide Tail Stock—Swing Rest for the Bench Lathe—Section of Turret Lathe Head Stock—Turret Lathe Head and Feed Box—Watch Movement—Development of Watch Movement—Another Gear Box—Valve Mechanism of Gas Motor—Assembly Drawing to Show Relation of Parts.

CHAPTER PAGE

IX. WORKING DRAWINGS 159

Bearing for Shaft—Drawing of Shaft Bearing—Shaft Box Cap—Hand Lever—Truck Wheels—Cap for Bearing Box—Fork Bracket—Connecting Rod Brasses—Connecting Rod with Brasses in Place—Connecting Rod for Gasoline Engine—Cylinder Head for Motor—Blow Off Valve Parts—Oil Feed Cock—Cylinder Cocks—Locomotive Pistons—Locomotive Cross Head—Driving Boxes—Locomotive Side Frames—Locomotive Side Rods—Steam Chest Valve Bushing—Piston Valve and Bushing—Locomotive Cylinder—Eccentric and Tabulated Dimension—Geared Pump Details—Box Support and Cap—Cast Brackets—Heavy Shaft Box—Surface Plate—Wall Bearing for Shaft—Steam Pipe Elbow with Bracket Connections.

X. WORKING DRAWINGS OF SMALL AND MEDIUM SIZED PARTS...... 189

Drawing of Typewriter Frame—Drawing of Typewriter Side Plate—Front and Rear Frame Braces—Universal Bar for Typewriter—Cone for Type Bars—Details of Bell Crank—A Set of Steel Cams—Simplifying Dimensions—The Use of Letters in Place of Dimensions.

XI. TOOL DRAWINGS 198

Reamers and Taps—Drawings with Tabulated Dimensions—A Boring Bar Drawing—Turret Lathe Tools—An Adjustable Slotter Tool—Reamers for Air Pump Valves—Valve Seat Tools—Tools for Boiler Check Bodies—Arrangement of Details on Valve Tool Drawing—Tools for Check Valve Fittings—Boring Tool for the Milling Machine—Reversible Drill Jigs for Eccentrics—Drilling and Boring Jigs for Lathe Apron—Apron Jig with Work in Place—A Set of Tools for Apron Operations—Long Boring and Reaming Bars—A Double Milling Fixture—Milling Fixture Details—Details of Punch Dies for Tie Plates—Press Tools for Typewriter Parts—The Blank Produced in the Dies—Precision Lay-Out for Dies—Tool Drawings in General.

XII. LIMIT DIMENSIONS ON DRAWINGS.......................... 219

Limits and Tolerances—The Meaning of the Term "Accuracy"—Necessity for Limit Gages in Parts Manufactured—Methods of Expressing Dimensions—Distinguishing Between Essential and Non-Essential Dimensions—Specifying Maximum and Minimum Sizes—Plus and Minus Limits—Simple Method of Specifying Dimensions—Illustrations of Applied Methods of Dimensioning—Pin and Bushing in Automobile Construction—A Pulley Example—Four Methods of Dimensioning a Pulley—An Important Principle—Dimensioning of Fuse Parts—Crank Shaft Drawing with Limit Dimensions—Limit Dimensions on Piston Drawing—Machine Gun Receiver with Limit Dimensions.

CHAPTER PAGE

XIII. ISOMETRIC AND OBLIQUE DRAWINGS—SHOP SKETCHES.......... 230

Uses of Isometric Drawings—Isometric Sketches of Punches and Dies—Isometric Cube—Isometric Circle and Cylinder—Examples with Cube and Cylinder—Three Positions of Circles—Correct and Incorrect Drawing of Circles—A Forming Tool Holder—Isometric Sections—Oblique Projections—Examples of Oblique Drawings—Oblique Sections—Shop Sketches—Eye Bolt—Bent U Forging—Angle Iron Sketches—Boring Bar Holder—Sketch of Die Bolster—Miller and Planer Tables—A V-Block—Facing Tool for Turret Lathe—Connecting Rod Forging—Connecting Rod Brass.

INDEX 245

DRAWING ROOM PRACTICE

CHAPTER I

DRAWING INSTRUMENTS AND THEIR USES

There are various makes of drawing instruments available to the draftsman and student and many combinations or sets in which such instruments may be purchased. Or, with a few of the essential tools to start with, these may be added to from time to time as deemed necessary or desirable. It may be stated at the outset for the encouragement of the beginner and for the benefit of the young draftsman just starting work in a regular drawing office that elaborate, expensive outfits of instruments are by no means essential to the production of high grade practical working drawings. And, it may be added, that many of our foremost draftsmen and designers acquired proficiency in their art with the aid of comparatively few tools, and these oftentimes of anything but the finest quality. By this statement it is not intended to discourage the purchase of highest class instruments, especially where one's means will permit of the outlay. As with other articles of utility, the particular grade of instrument and the number and variety included in an outfit must necessarily depend upon the individual's ability to purchase what he wants, or, more frequently, his willingness to make the best of what may be possible under his particular circumstances. The point is that it is entirely unnecessary to expend on a set of instruments a sum equivalent to a week or ten days' pay for a skilled machinist or tool maker.

The show windows of dealers throughout the country display a wide variety of drawing tools some of which are obviously of too crude and cheap construction to be of service to anyone desiring to take up the study and practice of drafting. But any reliable dealer may be depended upon to be of real assistance in the selection of an outfit of instruments suitable for the student of drafting and serviceable for the making of real commercial drawings.

The firm of Theo. Alteneder & Sons have long been known as manufacturers of fine drawing instruments in America. More recently the Keuffel & Esser Company have taken up the making in this country of their own well known line of high grade instruments.

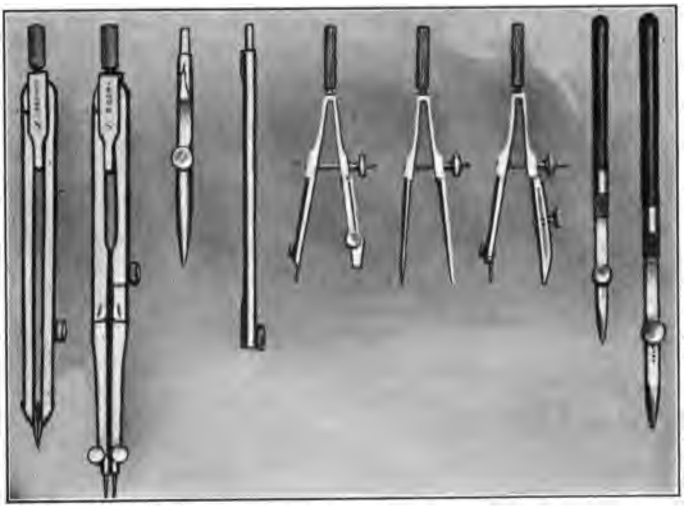


FIG. 1.—Set of Drawing Instruments.

An illustration of a set of instruments as manufactured by the latter company is presented in Fig. 1. These are high grade tools of simplified form and made to be sold at a reasonable price. The set includes the following instruments, all of which are an essential part of the draftsman's outfit of tools and materials.

Hair Spring Divider, 5¾ inch.

Compasses, 6½ inch, with fixed needle point, pencil point, pen and lengthening bar.

Steelspring Bow Pencil, 3¾ inch, with needle point.

Steelspring Bow Divider, 3¾ inch.

Steelspring Bow Pen, spring blade, 3¾ inch, with needle point.
Drawing Pen, upper blade with spring, 4½ inch.
Drawing Pen, upper blade with spring, 5½ inch.
Lead Box, containing six leads.

A list such as the above will cover the instruments proper which the draftsman requires for general drawing. It should be noted that whatever instruments are bought, they should be secured in a suitable case so that they may be properly taken care of at all times.

Considering now other essential materials and tools for drawing in addition to the instruments noted above, these may be listed as follows:

Drawing Board and Paper.
T-Square.
Scale, Architect's Triangular, 12 inch.
Triangles, one 45 degrees, preferably 8 inch; one 30-60 degrees, 9 inch.
Protractor.
Curve, Irregular (or French).
Pencils, one each 2-H, 4-H and 6-H.
Thumb tacks and small common tacks (1-oz.).
Drawing Ink, black waterproof, in bottle with filler attached to stopper.
Writing Pens, Medium.
Pencil and Ink Eraser.

Naturally one will gradually accumulate a few other simple articles of service, such as a fine file for pointing pencils, a small oilstone for touching up ruling pens, a steel scraper, etc.

DETAILS OF EQUIPMENT

Ordinarily the drawing board is made of white pine, clean grained and cleated. The size selected by the student working by himself is not of special importance except that it is desirable to use one large enough to approximate fairly closely the practice of the general drawing office. This will enable the amateur to familiarize himself with real work-a-day conditions more readily than if he uses too small a board for his home practice. A 24 by 30 inch board is a convenient size and the T-square should be of about the same length as the board.

The T-square commonly used is of hard wood with fixed head, a characteristic form being shown in Fig. 2. Occasionally on some classes of work it is convenient to have a double head or adjustable head T-square like Fig. 3. One head is here arranged to swivel to any desired angle and it is therefore an easy matter (for example) to draw a series of parallel lines across the board at any desired slope. Generally speaking, however, the one solid head square with head at right angles to the blade serves very fully for the making of machine drawings.

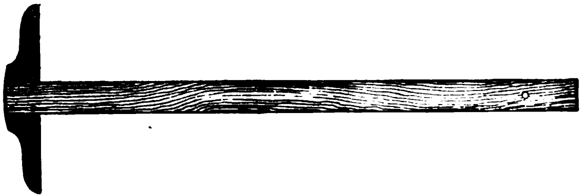


Fig. 2

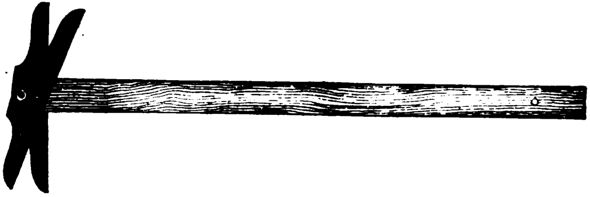


Fig. 3

T-Squares.

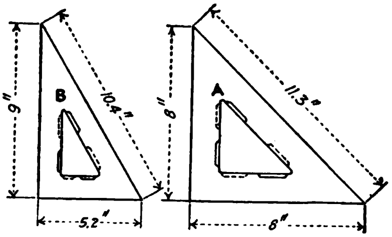
Scales are made of boxwood, steel or brass nickled plated, and of either triangular or flat form. A triangular scale is shown in Fig. 4. As used for machine drawing this is known as the "architect's" scale, the graduations being in so many inches or parts of an inch, to the foot. Thus, the different corners on such a scale would be divided, say, to scales of ⅛, ¼, ⅜, ½, ¾, 1, 1½, 2, 3, and 4 inches to the foot, and to 16ths of an inch. The "engineers's" scale, so called, differs

Fig. 4.—Triangular Boxwood Scale.

from the "architect's" in that it is divided into decimal parts of an inch and decimal parts of a foot.

Flat scales are often preferred to the triangular form as they carry only two lines of divisions and these are not easily confused. The triangular scale however combines in the one piece all of the scales commonly required and with a little practice there should be no difficulty in selecting the corner with the desired graduations. Moreover, in actual drawing practice there is seldom any change, or more than one change, in the scale on any given drawing and if under these circumstances there is found to be trouble in finding the proper scale quickly this is overcome easily by slipping a clip or guard over the uppermost corner so that the scale will naturally rest with the desired graduation on the paper.

Triangles are made of various materials. The celluloid or transparent type is best suited to general work. Hard rubber is apt to crock or smut the paper and wood triangles are likely to prove unreliable for accurate work. The two triangles referred to in the above list of tools, namely 45 degree, 8 inch, and 30-60 degrees, 9 inch, will have the sides proportioned as indicated by the sketches *A* and *B*, Fig. 5.



30-60° 45°

FIG. 5.—Triangles.

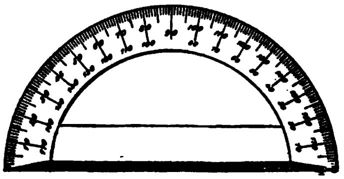


FIG. 6.—Protractor.

The protractor may be of metal as in Fig. 6, or of transparent material. The metal protractor is of course the more accurate tool. But in some instances the transparent feature of the other protractor is of great convenience.

Curves are made in many forms, but for machine drawing one shape will usually suffice. Fig. 7 illustrates a common curve which will answer about every purpose on this class of work. As with triangles the celluloid or composition curve is most satisfactory. This appliance is used for drawing curved lines which are not parts of true circles, and sometimes for drawing approximate circular arcs of large radius.

Drawing pencils are designated by letters which indicate their degree of hardness or softness, the range of hardness being from HB and F (or medium) to H, 2H, 3H, and so on up to 8H, while the soft grades range down from medium to B, 2B, 3B and so on to 6B which is very soft. For practically all work but the very closest layouts the 6H pencil is hard enough and in fact is considered by many to be too hard for drawings that are to be traced as it is oftentimes difficult to follow too fine a line through the tracing cloth. Many draftsmen prefer the 4H pencil for general line work. Figures, letters, notes, etc., are best put in with a 2H pencil. Where drawings are not traced or inked in they require a heavier line and here again the 4H pencil is an advantage.

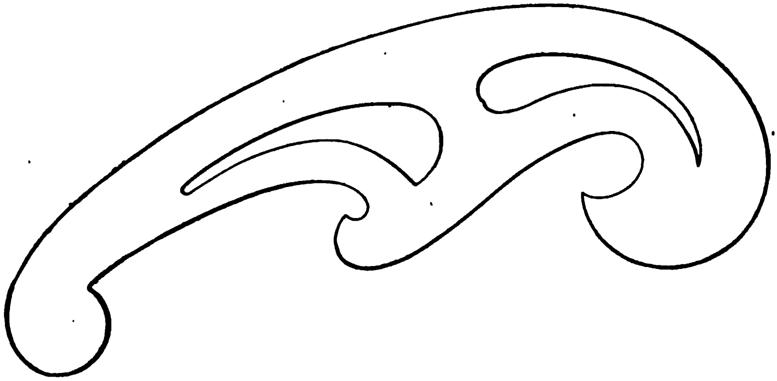


FIG. 7.—French Curve or Curved Ruler.

It is usually recommended that pencils for line work be filed up or sandpapered to a flat chisel edge or wedge shaped point in order to insure a keener edge and longer service before re-sharpening. This practice is preferable where many long lines are to be drawn, but is not always followed by skilled draftsmen who frequently use the fine round point for lines as well as for pointing off dimensions and the like.

Drawing ink supplied in small bottles is readily applied to the drawing pen, and bow pen, by means of a quill filler attached to the lower end of the cork. This filler is cut away at the side like a quill pen and when the cork is removed the end of the filler is placed between the pen nibs or blades to allow a small quantity of ink to enter the pen. Only a small amount of ink should be placed in the pen at a time as otherwise too free a flow will occur from the pen point. Ink should never be permitted to remain in the pen a moment after the completion of any given job of inking in. Even though the pen is laid aside for only a moment or two it should be cleaned at once by means of the wiper which accompanies the ink bottle in its package. Dried or partly dry ink in the pen is a nuisance and much time may be wasted in cleaning the instrument if the thin film of ink is permitted to harden and adhere to the inner surfaces of the pen blades.

In drawing a line with the ruling pen the latter should be held so that it will stand square or perpendicular to the edge of the T-square or triangle when seen from the end as in Fig. 8. If the handle is tipped toward the user the bottom of the pen will produce a line more or less irregular in its character, while if the handle is inclined away from the user so that the point swings in against the lower corner of the T-square the ink will be apt to flow under the square and blot the drawing. Looked at from the front of the drawing board however, the pen handle should be inclined slightly to the right or in advance of the pen point so that the pen will be *drawn* along over the paper and have a free, smooth action.

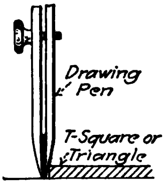


FIG. 8.—Use of Ruling Pen.

Constant use of the drawing pen produces more or less wear on the nibs or points and these are taken care of from time to time by touching up on the ends and outsides of the points on the oilstone, an operation which will be understood by the machinist and toolmaker without special explanation.

The paper commonly used for machine drawing is preferably a buff or yellow detail paper which may be purchased by the roll or by the yard and cut off to suit the width of the drawing board. Ordinarily the paper may be fastened satisfactorily to the board by means of thumb tacks, preferably of a small size, at the corners; but where it is desired to use extra tacks along the edges or necessary to work with T-square or triangle close to the edge, common small tacks, (½ or 1 oz.) are preferable as they can be set flush into the paper surface and thus be entirely out of the way of the tools that have to be passed over them.

USE OF THE T-SQUARE AND TRIANGLE

The position of the T-square on the drawing board is indicated in Fig. 9. The head of the square is always placed against the left-hand side of the board and horizontal lines are drawn along its upper edge from left to right. The T-square head must be pressed firmly and squarely against the edge of the drawing board by means of the left hand and sufficient pressure must be maintained by the hand to prevent the T-square from rocking while the horizontal line is being drawn along its edge. The triangle is used for the drawing of vertical lines and it is placed against the T-square blade with its vertical edge to the left, the line being drawn from bottom to top. When using the triangle, the head of the T-square is held in proper contact with the edge of the drawing board by the thumb of the left hand which rests on the blade or by the ball of the hand, while the triangle itself is moved along the blade of the square as required, by the fingers.

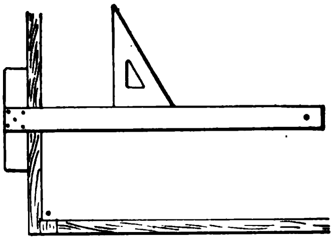


FIG. 9.—T-square and Triangle on Drawing Board.

Suppose we are to draw a rectangular outline as shown at *A*, Fig. 10: Having cut a sheet of paper somewhat smaller than the drawing board and tacked it thereon and drawn border lines along the paper ½ to ¾ inch inside the paper edge, we select a suitable place for the drawing proper according to its size and scale, and draw horizontal line *a-b* along the T-square from the left to the right, making this line a little longer than the length of the drawing required. On this line point off the exact length desired by means of the scale and a sharp pencil, or by a prick point, and then draw a vertical line *a-c* along the edge of the triangle which is held with its left edge coincident with the pencil point at the left end of the horizontal line *a-b*. We can then point off on *a-c* the exact length of the vertical line desired, slide the T-square up the board and draw the horizontal line *c-d*. Then the triangle may be moved to the right and the second vertical line drawn at *b-d*. The lines are all drawn very lightly and all of them naturally over run the true points of intersection with one another. The lines may therefore be gone over again to strengthen them, care being taken to stop each line at its corner intersection with the other lines. If however the drawing is to be inked it is unnecessary to run over the lines a second time with the pencil.

The drafting student should practice drawing simple rectangular outlines and similar figures until he can lay off his dimension points readily and set his T-square and triangle and draw the lines quickly.

While the 45 degree triangle is shown in Fig. 10 on the T-square it is really immaterial which triangle is used. Either the 60 or 45 degree triangle is applied according to convenience. Ordinarily the 30-60 degree triangle is preferred with its long edge placed vertically on the board, as it then permits the drawing of lines of considerable length.

Not all lines drawn with the T-square are horizontal, for occasionally lines are required to run at an angle across the paper and in such cases the square is swung around to the required slope as, for example, in Figs. 11 and 12. In this position the triangle is used with the same facility as when the T-square is placed horizontally. In Fig. 11 some part of a machine detail is shown set at an angle with the horizontal base *B*, the inclined upright portion *A* being drawn with square and triangle inclined accordingly. The lines *C* and *D* are drawn with the left side of the triangle just as if they were vertical lines. But in order to "cross hatch" the portion shown exposed, at 45 degrees, the triangle has been turned over to bring the 45 degree slope to the left. Cross hatching is done to show a section through a piece and so distinguish it from an external view. This will be referred to at length in later chapters.

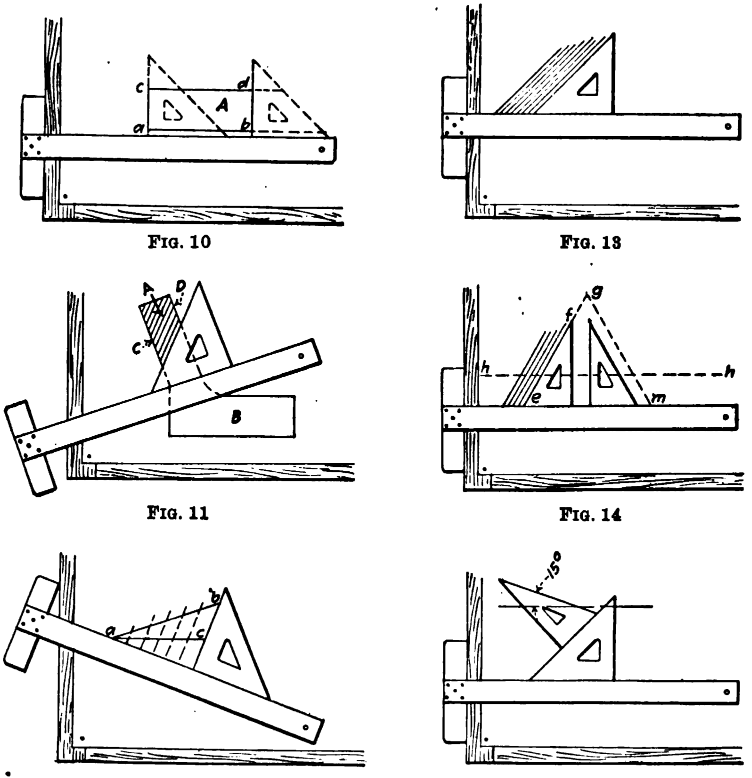


Fig. 10 Fig. 13

Fig. 11 Fig. 14

Fig. 12 Fig. 15

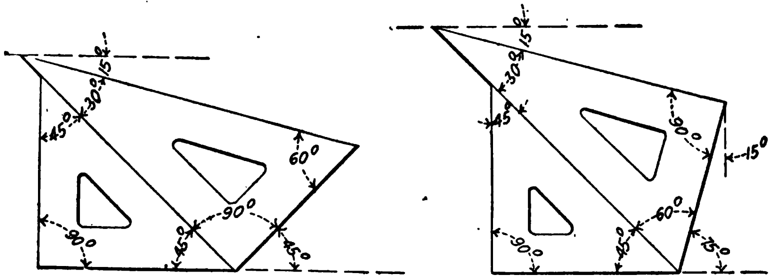
Applications of the Triangles and T-square.

The illustration, Fig. 12, is another common example of the use of T-square and triangle at an angle to the horizontal. In this instance they have been set around as shown to transfer the sub-dividing points on slant line *a-b* to base line *a-c*.

FURTHER APPLICATIONS OF THE TRIANGLE

In Fig. 13 the 45 degree triangle is illustrated as used along the horizontal T-square blade for ordinary cross hatching, and in Fig. 14 a 60 degree triangle is shown similarly positioned, but of course for 60 degree instead of 45 degree lines. This view shows how the sloping line at 60 degrees to the horizontal may be extended and if desired joined by a similar line from the opposite direction. After the slanting line *e-f* has been drawn with the triangle in the position indicated, the T-square can be moved up to another position as *h-k* and line *e-f* extended as required, say to *g*. Then, if the triangle is turned over, line *m-g* may be drawn from the opposite direction to join *e-g* at *g*.

Familiarity with the possible uses of the triangle will prove of benefit to the young draftsman. The two triangles (45 and 30-60 degrees) admit of various uses in combination and often they are used together in preference to the T-square on parts of small and medium sized drawings. In Fig. 15 the two are shown so set as to give an angle of 15 degrees to the edge of the T-square or horizontal line. The diagrams, Fig. 16, show angles obtained at once by combination of the two triangles. Figs. 17, 18 and 19 illustrate common uses of the triangles independently of T-square where the face of the one triangle is long enough to form a working edge for the other. Practice with the triangles enables the user to work very rapidly in laying out 60 degree, 90 degree and other angular parts which may or may not be located along horizontal or vertical center lines on the drawing.



(a) (b)

FIG. 16.—Combinations of Triangles.

DIVIDERS AND COMPASSES

Dividers are useful in laying off points on given lines and particularly for spacing off different short lengths and for dividing lines and circles into equal parts.

Taking, for example, line *AB* Fig. 20, it is desired to divide this line into five parts of equal length. Starting at point *B* we can open the dividers by inspection to approximately one-fifth of the line length *AB* and step of the points 1, 2, 3, 4, 5, the last of which will usually fall short of *A* or on the other hand over run that point. Say it fall short by the amount represented by *C*. We then reset the dividers by opening them by an amount equal to *5-D* which is, as close as we can estimate, one-fifth of distance *C*. Then starting again at *B* we space off the points

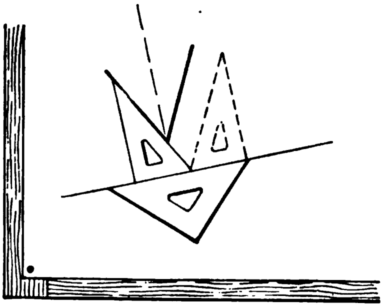


Fig. 17

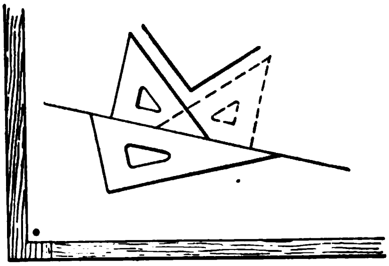


Fig. 18

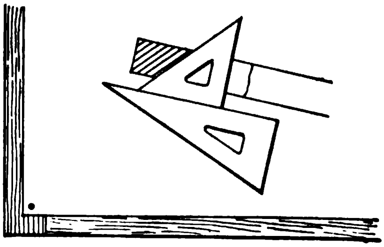


Fig. 19

Uses of the Triangles.

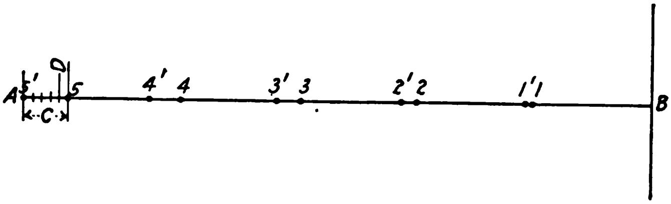


Fig. 20 —Dividing a Line into Equal Parts.

1′, 2′, 3′, 4′, and 5′, the latter falling on point *A* at the end of the line. Sometimes two or more trial settings are required to divide the line equally although with experience the second setting will almost always be correct.

Where the line *AB* is of such length that each subdivision will be in even inches or convenient parts of an inch, it is easier, of course, to use the scale directly and point off the divisions from the scale graduations. There are other methods too of subdividing lines which will be referred to later. When the line such as *AB* stands by itself without construction lines at either end it is usually more convenient to start spacing from the left end (as *A*) and space to the right. The dividers are held easily by the small head at the top and twirled, clockwise direction, between the thumb and first two fingers.

The compasses with either pencil or pen are held in similar fashion. The instrument is revolved clockwise and in drawing circles the pencil or pen as the case may be, should be slightly behind the head and hand at the top so that there shall be a slight dragging movement which will result in a smooth line. If the instrument is held vertically there is likelihood of the pencil or pen point being pushed ahead instead of drawn along smoothly and a chattered uneven effect will be produced.

In starting to scribe a circle as Fig. 21, the compasses should be twirled well back by the fingers and the starting point made as at *A* well back toward the right-hand end of the horizontal center line. Then the circle may be drawn complete with an easy rotation of the instrument and without cramping of the fingers. Some draftsmen start the circle even further back or well toward the top of the vertical center line. Practice with the compasses will determine the best starting position for the individual but in any event it must be well back toward *A* or even farther back if smooth circles are to be drawn readily.

DIVIDING THE CIRCLE

Suppose a circle Fig. 22, is to be divided into 7 parts by the dividers and without reference to a table of chords.* The problem is practically the same as the straight line division in Fig. 20. The dividers are set by inspection to approximately correct opening and the divisions marked 1 to 7 spaced off. We find say that the seven points come short of the complete circle by an amount represented by 7-7^2. We then open the dividers by an amount approximately one-seventh of the gap 7-7^2. If the resetting is accurate the dividers will now space off the circle correctly, but assuming that they are set still a little under the requisite degree of opening, the points on the circle will come as at 1′, 2′, and so on to 7′. Another adjustment of the dividers is now required equal to one-seventh of space 7′-7^2 and the third trial gives us the equal spaced points 1^2, 2^2, and so on around.

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* Tables of chords are given in the "American Machinists' Handbook," by which the dividers may be set at once to the length necessary for spacing any number of divisions in circles of different diameters.

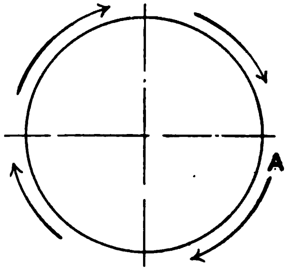


FIG. 21.—Drawing a Circle.

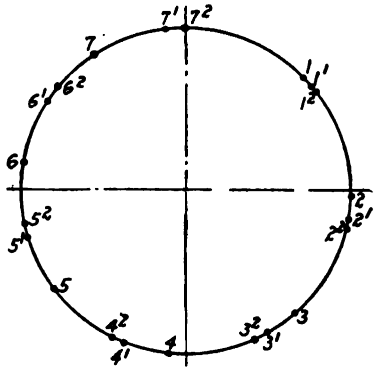


FIG. 22.—Dividing a Circle into Equal Parts.

The protractor is also useful in laying off divisions on circles. Referring to Fig. 23, we wish to divide the circle shown into say, nine divisions. As there are 360 degrees in a circle, it is apparent that each division of the nine will be equal to 360 degrees divided by 9, or 40 degrees. Now, setting the protractor on the horizontal center line with the center of the protractor on the intersection of the horizontal and vertical center lines, mark the points 1, 2, 3, 4, opposite 40, 80, 120 and 160 degrees. As the ordinary form of protractor is not graduated beyond the half circle or only a few degrees beyond, the protractor is now set to the lower half of the circle and the remainder of the 40 degree divisions pricked off on the drawing. Radial lines drawn with the triangle set to the center of the circle and extending across the points laid off at 1, 2, 3, 4, etc., can now be drawn across the circle to form the dividing lines at 40 degrees apart, as 1′, 2′, 3′, etc. The lines are merely short ones cutting the circle and may in fact be nothing more than sharp dots on the circle itself.

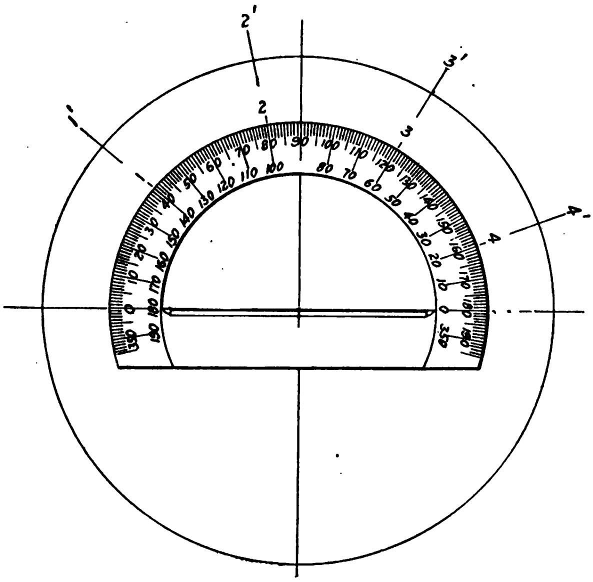


Fig. 23.—Use of the Protractor.

Usually protractors are not over 5 or 6 inches in diameter and the dividing of circles of considerable size is therefore best done—if close accuracy is essential—by stepping off directly with the dividers, particularly if a table of chords is available for immediate setting of the dividers to exact distance.

SUGGESTIONS FOR PRACTICE

For a little practice in dividing lines and circles the student may draw a 4¼ inch straight line as in Fig. 24 and divide

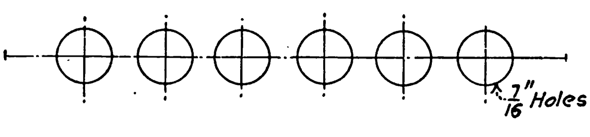


Fig. 24.—Circles Spaced on Straight Center Line.

this into 4, 5, 6, or 7 parts and then draw a series of $^7/_{16}$ inch circles with the compasses to represent bolt holes as in a plate or bushing holes as in a jig. Then he may draw a circle of any convenient diameter say 3½ inches and lay off 18 hole centers as in Fig. 25. These would be 20 degrees apart as indicated. Other sizes of circles should also be drawn and other numbers of holes spaced off either by protractor or by dividers and then holes should be drawn to represent say, index holes as in a plate. While no outline is shown of either object in Figs. 24 or 25, as these are merely skeleton problems in dividing lines and circles, the student will do well to exercise his mind and hand by outlining around these skeleton forms some simple design of jig plate, or other shop object with which he may be familiar.

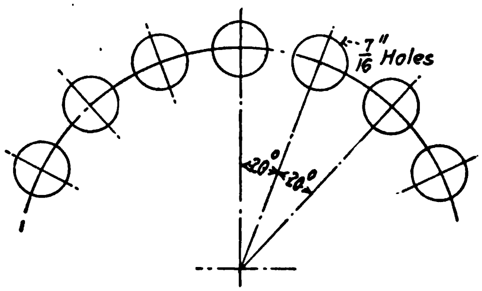


Fig. 25.—Circles Located on Arc.

A simple suggestion in this immediate direction is contained in the sketch, Fig. 26. This represents a simple cast plate as seen from the top (or in plan) with two holes near the upper edge. It will be noticed that the corners of the casting are well rounded as is generally the case with this class of work and in drawing the lines in clearly after the object has been

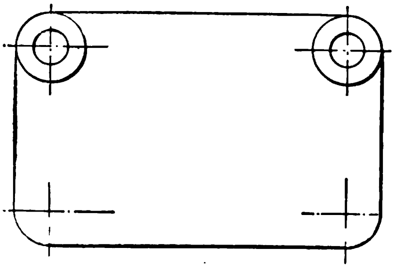


Fig. 26.—Simple Jig Plate with Holes and Bosses.

laid out carefully in light lines, it is well to draw all circles first and especially so with the round corners which are joined by straight lines. It is always easier to draw a straight line to just meet the edge of a circle or arc of a circle than to draw the circles to match the straight lines. This is especially the case with drawings that are to be inked. All circles and arcs should be inked in first and the straight lines drawn afterward.

A good example for practice in the drawing of arcs is found in Fig. 27 which shows the side plate of a chain with a circular arc in the center joining the two upper circles and a straight line at the bottom connecting the circular ends. Layouts of this character can be made to various sizes to give the student exercise in performing neat and rapid work of this kind.

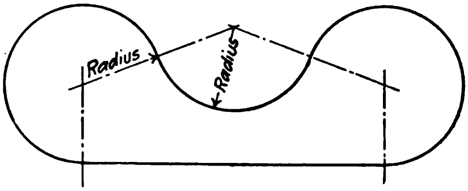


FIG. 27.—Showing Joining of Curves and Straight Lines.

APPLICATION OF THE CURVE

The use of the irregular curve is indicated in Fig. 28. Portions of the curve are shown by the two sets of dotted lines marked "Outline of Curve 1st and 2nd Position." There are in this case three points, *A, B,* and *C,* which are not part of a circle, but which are to be joined by a smooth curve, and it is usually easier in such cases and more satisfactory, so far as results are concerned, to use the curve than to try to set compasses to the necessary positions. The curve is first set by inspection until some portion is found which will join *A* and *B* and extend in the general direction of *C* and then the second setting is made to join the first part drawn and the third dot *C*. A few trials with the curve will enable the user to quickly select the best portion of the edge for any given combination of centers through which the curve is to be drawn. The curve is a very handy appliance in the laying out of certain types of cams, certain parts of machine frames, handles, levers, pulley arms and a host of other shop details where compasses are of too limited range or inconvenient because of the larger number of settings and centers that would be required. On certain classes of work where it is necessary to adhere to circular arcs in order that the work may be made up properly in the shop,

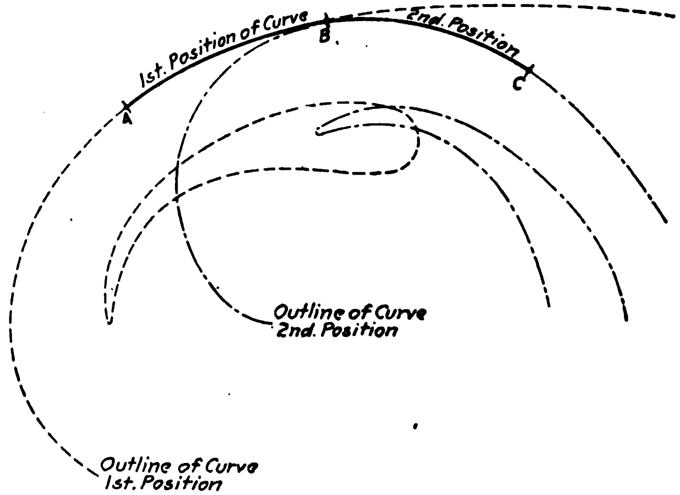

1st. Position of Curve
2nd. Position
A
B
C
Outline of Curve 2nd. Position
Outline of Curve 1st. Position

FIG. 28.—Application of Curved Ruler.

the curve may be used for the laying out on the drawing board and then the curved lines thus located can be used as guides to which the compasses may be conveniently set for establishing radius and lengths of arcs corresponding so closely to the original curve as to be fully satisfactory.

EXERCISE IN DRAWING SIMPLE LINES AND CIRCLES

A good deal of attention should be paid to the drawing of simple lines and circles until smooth straight lines and circles are readily made and after a reasonable degree of skill has been attained in the use of the drawing pencil and compass with pencil point, the student should take up the use of drawing pen, compass with pen, and bow pen. Skill with either pencil or pen can come only with practice. The circles in Fig. 29 are excellent examples for practice as they are made up of plain and broken lines, both light and heavy and should be drawn in various diameters with pencil and afterward with compass and pen. As rapidly as the hand becomes expert in the handling of pencil exercises the student should pass on to the use of the pen. First attempts at inking in will undoubtedly appear somewhat awkward and lacking in skill but with care and experience difficulties will be overcome.

Another good example for developing skill, particularly in inking in, is found in Fig. 30. The circles just touch at their extremities and some little patience must be exercised if a good outline is to be preserved. Even with the compass and pencil point there will be found a tendency for the circles to just miss or to cut through one another rather than to blend smoothly and this difficulty will be increased in the inking in process.

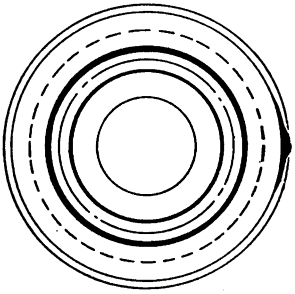


FIG. 29.—Full and Dotted Circles.

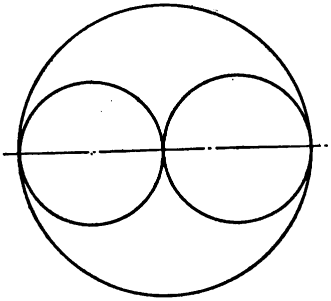


FIG. 30.—Drawing Circles in Contact.

The two smaller circles should be drawn first and the larger then drawn to just enclose them. It is hardly necessary to add that when inking in a layout of this kind, each circle should be allowed to dry thoroughly before inking in the next.

A FEW SIMPLE PROBLEMS FOR THE DRAWING BOARD

There are many problems in the construction of geometrical figures, and in the laying out and dividing of lines, angles and circles the solution of which would be of value to the student in the way of giving him preliminary experience with a variety of problems which arise in real work over the drawing board. A few simple examples of such problems are given in Figs. 31 to 36 inclusive. Others will be discussed in connection with practical examples of drawing work in later chapters.

TO BISECT A STRAIGHT LINE

In Fig. 31 it is required to divide the line *AB* into two equal parts. With the compasses set to some length greater than one half of *AB* we strike the arcs *ad* and *a'd'* using *A* as the center, then strike arcs *bc* and *b'c'* from *B* as a center. The points where the arcs intersect at *CC'* are equidistant from the ends of the line *AB* and by laying a ruler or straight edge along these points a line can be drawn across line *AB* which will bisect it.

TO ERECT A PERPENDICULAR TO A LINE

A somewhat similar problem is that in Fig. 32, to erect a perpendicular to line *AB* at any point, *C*. Taking *C* as the center point for the compasses, lay off two points *a* and *b* by swinging the pencil point of the compasses across line *AB*. The distance struck from center *C* is not important but accuracy is assured by taking *Ca* and *Cb* about as long as the short end of the line *AB*. Then from *a* and *b* as centers, strike the arcs *ad* and *a'd'* and *bc* and *b'c'*. The ruler may then be placed across the intersecting points of these two sets of arcs and line *CD* drawn perpendicular to horizontal line *AB*.

TO DIVIDE A LINE INTO EQUAL PARTS

The problem in Fig. 33 is the dividing of a line *AB* into a given number of equal parts, without making trial steps with the dividers. For this purpose, draw a line *AC* at any convenient angle to *AB* and step off on this line from point *A* the same number of divisions as are required for *AB*, in this case, six. These even divisions on *AC* are taken at any convenient length, only the last point 6 should fall inside the end of the line *C*. A T-square blade or triangle is then placed obliquely on the board and adjusted until another triangle placed against it will cut points 66 on both lines *AB* and *AC*. That is, the edges of the triangle must intercept the end of line *AB* at 6 and line *AC* at 6 also. Now without moving the lower or base triangle, slide the second triangle along to the left and when it intercepts point 5 on AC mark off the division 5 on AB. This process is continued with each division on AC until all have been transferred to AB. The operation will be easily understood by referring back to Fig. 12, which shows clearly the method of setting the T-square or main triangle around at an angle to permit the upper triangle to transfer the points on the sloping line to the line which is to be divided in even parts.

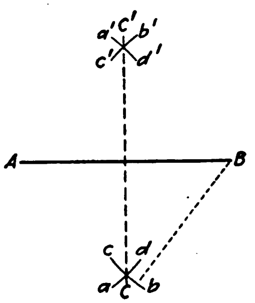


Fig. 31

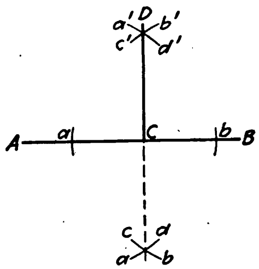


Fig. 32

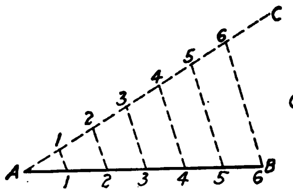


Fig. 33

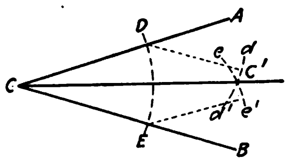


Fig. 34

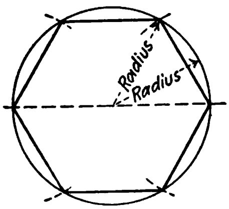


Fig. 35

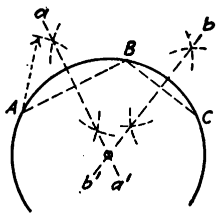


Fig. 36

Simple Problems on the Drawing Board.

TO BISECT AN ANGLE

We have an angle ABC Fig. 34 which we are to bisect. From C as a center strike are DE cutting CA and CB as shown. From

D as a center strike short arc *dd'* and from *E* as a center and with the same radius *Dd* strike similar arc *ee'*. A line through the point of intersection of these two arcs at *C'* and through *C* will divide the angle in two equal parts as shown.

TO CONSTRUCT A HEXAGON

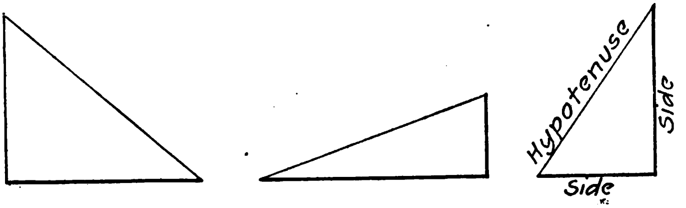
The hexagon is a very common form in mechanical drawing. It is the shape of ordinary nuts and bolt heads and is one of the details most frequently found in drawing. Generally the diameter across corners is known and the hexagon is therefore usually drawn inside a circle of the same diameter as the distance across corners of the hexagon. First the circle is drawn, Fig. 35. Then keeping the same radius as for the circle, step off the six points around the circle. Then draw the lines connecting these six points. In other words, the flat of the six sided figure is exactly equal in length to the radius of the circle in which the hexagon is described.

TO FIND THE CENTER OF A CIRCLE FROM TWO FLAT SIDES

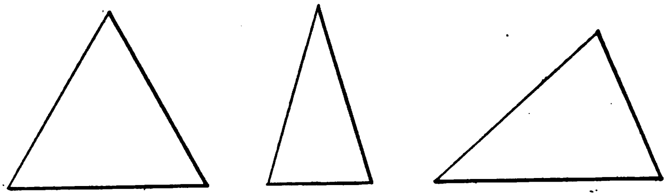
Sometimes in die making and other tool work we have a design with say two flat sides which may be of different lengths and around which we wish to draw a circle of such diameter that its circumference will just touch the corners of the flats. The center of such a circle will then give us an accurate working point from which the die or punch can be laid out and machined. In Fig. 36 two flat sides of such a design are indicated by lines *AB* and *BC*. We wish to draw a circle just touching corners *ABC*. Following the principle described in connection with Fig. 31 we bisect line *AB* allowing the line *aa'* to extend well past the intersection of the inside arcs. Then we bisect line *BC* and carry line *bb'* across line *aa'*. The point where the two lines cross will be the center of the circle.

TRIANGULAR FIGURES

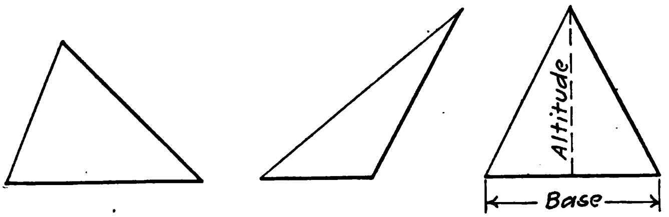
The triangular figure in its various forms appears very frequently in mechanical drawing and Fig. 37 should be examined carefully in order that the reader may become familiar with the different forms of triangles. Thus we have shown right angle triangles, where one angle is right or 90 degrees; the equilateral triangle where all three sides are equal; the isosceles triangle where two of the sides are equal; the scalene triangle in which no two sides are equal; the acute triangle where all angles are acute; the obtuse triangle which has one obtuse angle.



Right-Angle Triangles



Equilateral Triangle Isosceles Triangle Scalene Triangle



Acute-Angle Triangle Obtuse-Angle Triangle

FIG. 37.—Triangles.

THE LINES USED ON DRAWINGS

Although we have not yet reached the study of actual working drawings it will be well at this point to consider briefly the common lines used for general mechanical drawing. To the skilled mechanic accustomed to reading drawings and blue prints, each line has a definite meaning and certain lines are used almost universally over the manufacturing world. In

Fig. 38 the common lines are shown with a brief explanation at the right of each line. And in Fig. 39 a simple drawing is reproduced showing the actual use of such lines. In this drawing the view to the left is what is known as a partial longitudinal section in which the upper portion of the view is cut away to show the section through the outer member *A* and the body of the shaft *B* which passes through it.

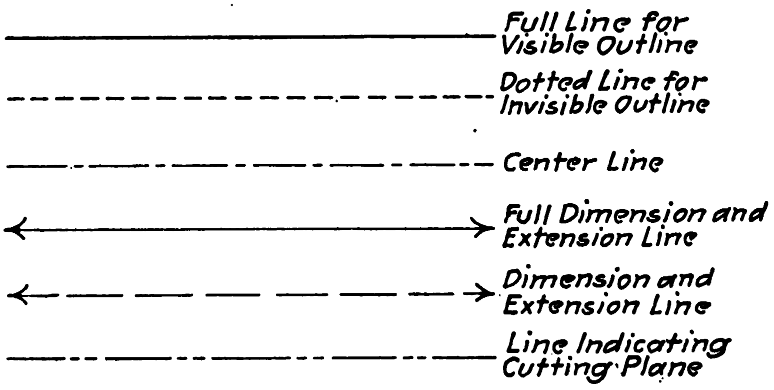

Full Line for Visible Outline
Dotted Line for Invisible Outline
Center Line
Full Dimension and Extension Line
Dimension and Extension Line
Line Indicating Cutting Plane

FIG. 38.—Lines Commonly Used on Drawings.

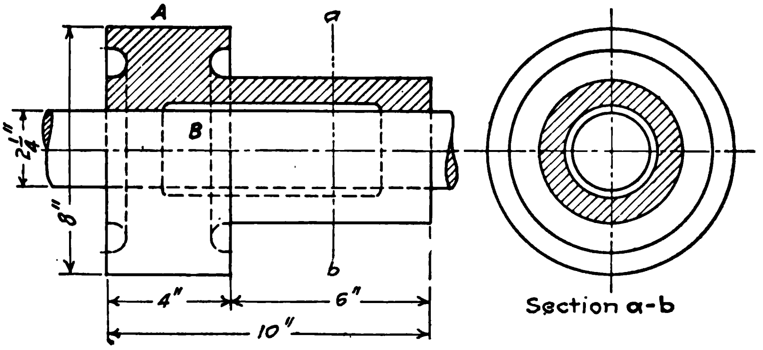


FIG. 39.—Showing Uses of the Various Lines in Fig. 38.

LETTERING

The lettering on mechanical drawings is usually of a simple character, and the most common form is the Gothic letter seen in the upper alphabet in Fig. 40. The lower case letters or small letters used with such capitals are of the well known italic form in the lower line of Fig. 40. Ordinarily it is well to make the capitals about $^3/_{32}$ inch high with a slight slope say 15 to 20 degrees to the right. A conventional drawing title is shown in Fig. 41 with the firm name and name of the drawing in capitals and the descriptive lines in capitals and small letters. Where large numbers of drawings are made the firm name and regular lines for "Scale," "Drawn by," "Checked by," etc., are printed or stamped; in smaller drawing offices the entire title has to be printed by the draftsman and the student of drafting should devote sufficient time to such lettering to enable him to turn out a neat, presentable piece of title work.

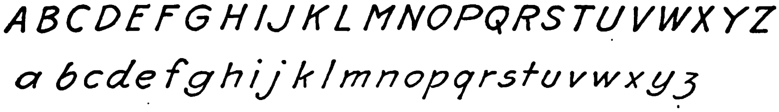


FIG. 40.—Type of Letter Commonly Used on Mechanical Drawings.

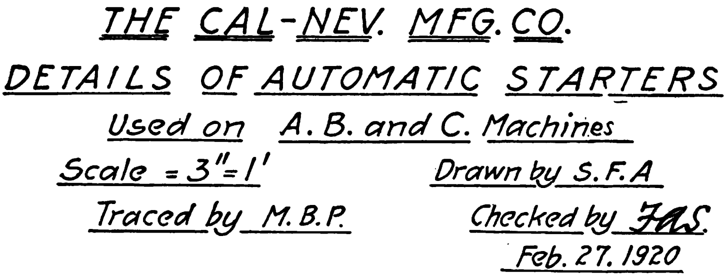


FIG. 41.—Drawing Title.

CHAPTER II

PROJECTION

Projection, in practical drawing, called orthographic projection, refers merely to the different views of a machine or part, such as the "plan," "front elevation," "side elevation," etc. Thus we call the plan view a "horizontal projection," and the front and side views "vertical projections." Looking down upon the top of the machine or object we see the plan view, and looking at the front and sides we see the front elevation and the side or end elevations.

It is the business of the draftsman so to construct the different views of an object as to enable each view to aid in the correct reading of the other views and thus give a true understanding of the drawing as a whole so that the part drawn up shall be made correctly by the worker in metal or wood as the case may be.

The skilled draftsman who is familiar with the details of shop operations, so selects and arranges his views on the drawing paper as to make each and every part of the object clear to the workman who, taking the drawing as his guide, must produce the actual piece in the shop. With plan, elevations and sections suitably arranged and properly dimensioned the completed drawing should be easily "read" by anyone acquainted with the "language" of drawings.

It is unfortunate that the practice as to the placing of different views on a drawing is not the same in all countries, as this condition leads occasionally to misunderstanding upon the part of American mechanics working from European drawings, and similarly causes a certain amount of trouble when foreign-trained workmen take up for the first time the drawings and blue prints made to the system of projection prevailing in this country.

It is almost universally the custom in the United States to place the views in a drawing so that the plan comes directly above the front elevation, the right side elevation immediately at the right-hand of the front view and the left side elevation (if one is required) at the left-hand side of the front elevation. The general English practice and in fact the system commonly followed throughout the plants of Europe as a whole is the exact opposite of that described above. This means that with their drawings, the right-hand elevation or the view of the right-hand end of a machine or part is shown at the *left* of the front elevation and the left side elevation at the *right.*

Examination of a number of different classes of drawings will indicate that in some few cases this practice has certain advantages, which will be touched upon in due course. In the main it is undoubtedly true that the more convenient method for both draftsman and user of drawings is to arrange the views in what is undeniably a logical manner, with the elevation of the right side or end immediately adjacent to and at the *right* hand of the front elevation; and the left hand elevation immediately to the *left* of the front view. For the same reason the plan of the top of the work is most readily identified with the front elevation when it is placed directly *over* the top of that elevation.

HOW OBJECTS APPEAR TO THE EYE

The difficulty experienced oftentimes by young mechanics in reading drawings and sometimes by young draftsmen in making drawings is due to the fact that the views or projections made on the drawing board are not like the view which is ordinarily presented to the eye when one looks at a casting, or other machine part lying on the bench or floor. That is, as one glances at, say, a cylinder, a bolt, a bed plate or some piece of mechanism, the view presented to the eye is usually a perspective of the object or practically the same view that would ordinarily be made by the camera where two or more sides or faces would naturally be included in the one photographic negative. Such a view is approximated closely by isometric drawing (which is discussed in another chapter) but practically all working drawings are made in orthographic projection that is with plan, elevations, and if desirable, additional views showing sections and partial sections. It becomes necessary therefore to accustom the mind's eye to visualize or see the different faces of the object as separate views, each properly related to the others so that the plan (or horizontal projection) and the front, side or end views (vertical projections) can be drawn on the paper in exact relation to one another.

Consider Fig. 42, for example: This is a reproduction of a photographic view of a rocker arm inclined slightly on the bench to allow the top of the hub and the width of the arms to be seen as well as the general length and the forked ends of the arms. Aside from the overall length all other dimensions are foreshortened by the camera. This is the view that would ordinarily be seen by the eye, but if a working drawing were required of such a piece with plan and elevations, it would be necessary to make one view looking directly down from the top which would show the diameter of the hub, the bore, the width, and length of the arms; and a view of the side or front elevation showing the height of the hub, the thickness of the arms, the width of the slot in the ends, the position of the pin holes in the forked ends. This front elevation would then appear like the photographic view in Fig. 43 so far as position is concerned, only the view would be outlined in pencil or ink instead of being a photographic print as in the half-tone.

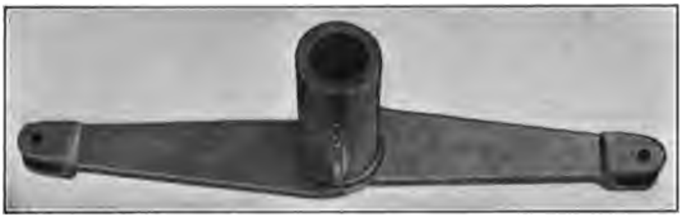


FIG. 42.—Photographic View of Rocker Arm.

Now consider Fig. 44: here we have three photographic views of a hollow shaft in the outside surface of which there are two cross grooves and a longitudinal groove. If a working drawing were to be made of this shaft there would be three views corresponding in arrangement to the views shown, one of these showing the grooves from the front, one with the shaft rotated through 90 degrees so that the depth of the end notches or grooves is seen, and one view of the end of the shaft showing its diameter and the diameter of the hole bored through its length.

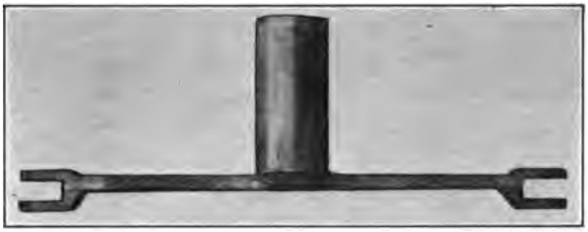


FIG. 43.—Photographic Side View or Front Elevation of Rocker Arm.

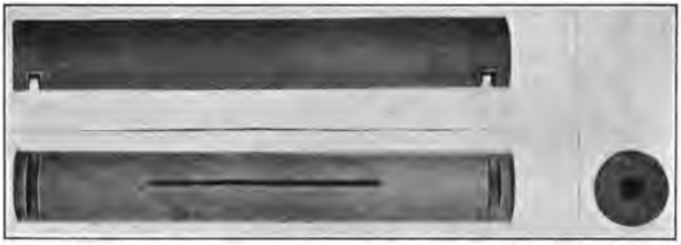


FIG. 44.—Three Photographic Views of a Hollow Shaft.

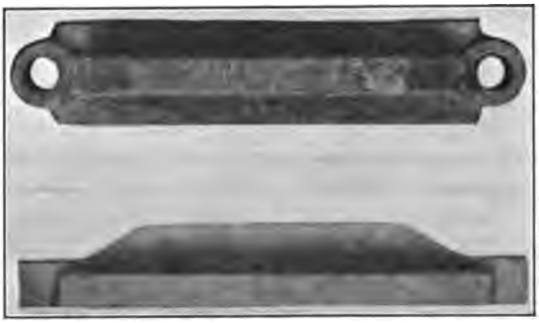


FIG. 45.—Photographic Views of a Bearing Cap.

In Fig. 45 we have the photographic views in plan and front elevation of a cast strap for the top of a pillow block, these views representing the casting just as it would appear to the eye if we were to look directly down on its top surface (plan) and then turn it up on its edge and look directly at the front edge (front elevation). In Fig. 46 we have the same casting drawn on the board in plan and front elevation. The plan is known as the horizontal projection and the elevation as the vertical projection. The plan is drawn in what is called the horizontal plane and the elevation in the vertical plane.

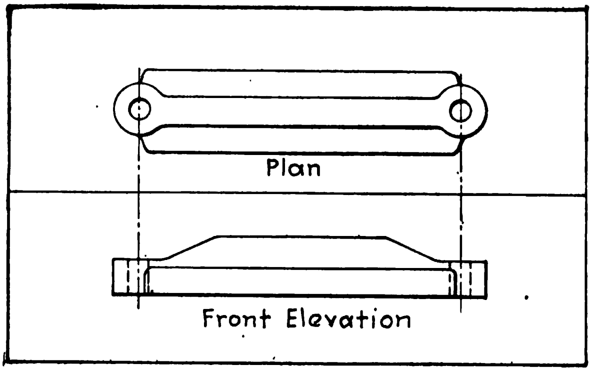


FIG. 46.—Arrangement of Views on Drawing Corresponding to Photographic View in Fig. 45.

DESIRABILITY OF AT LEAST TWO VIEWS FOR THE SIMPLEST DETAILS

In making drawings it is sometimes possible to show a detail satisfactorily with a single view as in the case, say, of a simple shaft which as seen in elevation would appear as a long rectangle; this can be shaded to resemble a cylindrical object and the diameter marked thereon. Such single views however usually require a number of explanatory notes and it is almost always safer and more convenient to the shop mechanics to have an end view in addition. Many errors are made in the shop for the simple reason that not enough views have been included in the drawing to make it entirely clear to the workmen. Examine Fig. 47: Here a number of objects are shown, all alike in elevation but differing completely in plan or end view. Only one of these is of cylindrical form (or similar to a short shaft) but all have the same appearance in elevation. In each instance the end view or plan added to the elevation shows at once the real shape of the detail.

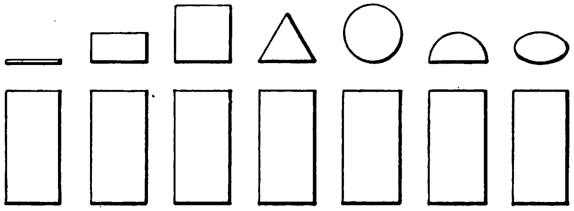


Fig. 47.—Various Shapes of Parts All Having the Same Front Elevation.

THE PLANES OF PROJECTION

Although, as pointed out, first-angle projection is seldom employed in this country, it will be touched upon briefly as a knowledge of its principles will lead naturally to a clearer understanding of third-angle projection, the system to which most of our drawings are made. That the latter is the more convenient of the two methods to both draftsmen and shop mechanics will be evident upon examination of Figs. 48 and 49 which show a simple detail in, respectively, first-angle and third-angle projections. In the former arrangement the end view showing the squared portion *A* is placed at the *opposite* end of the cylinder while with the third-angle method the end view with its squared portion is immediately adjacent to the same portion as shown on the longitudinal view. Where a long piece is drawn in first-angle projection the inconvenience of showing different views at the far ends of the longitudinal view is even more conspicuous.

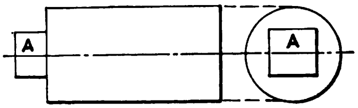


Fig. 48.—First Angle Projection.

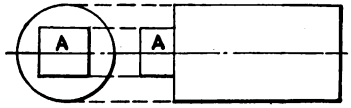


Fig. 49.—Third Angle Projection.

In Fig. 50 are shown the horizontal and vertical planes cutting each other at right angles; the four angles thus formed being designated in descriptive geometry as 1st-quadrant, 2nd-quadrant, 3rd-quadrant, and 4th-quadrant. The line *A-A′* which is the axis common to both planes is called the ground line. This line is actually horizontal as laid out on the drawing board, but in Fig. 50 it is shown at an angle to correspond to the perspective sketch of the horizontal and vertical planes. The pictorial effect secured by representing the planes in perspective will enable the reader to understand readily the method of projection.

FIRST-ANGLE PROJECTION

Now suppose we have the simple block *B* to be drawn in first-angle projections: This means that we are to imagine the block as actually located in the 1st-quadrant while we transfer its outlines to the horizontal and vertical planes. If we were to suspend such a block in the position indicated in Fig. 50, and look down directly from the top we could transfer the outline of the top or plan *P* directly onto the horizontal plane as at *P′*. Then by looking directly at the face *FF*, or front of the block we could transfer that face onto the vertical plane and secure the view known as the front elevation which is indicated at *F′*. That is we would draw on the horizontal plane the top face *P* just as it appears when seen from the top; and on the vertical plane the front face or elevation *F* as seen from the front. Then if we swing back the vertical plane about the

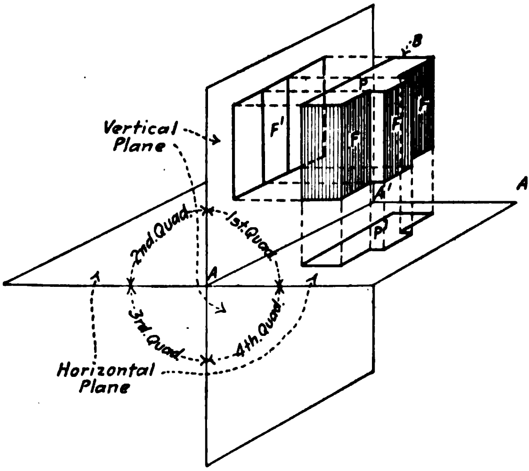


FIG. 50.—Geometrical Arrangement of Views in First-Angle Projection.

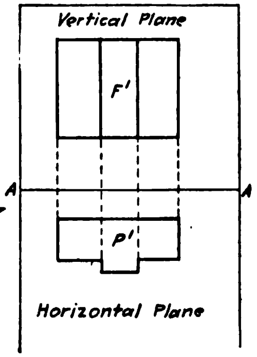


FIG. 51.—Views as They Appear on the Drawing in First-Angle Projection.

common axis or hinge *AA'* until it lies flat or forms a continuation of the horizontal plane, we have the effect produced in Fig. 51 which shows the actual relative positions of the two views when made on the drawing board in first-angle projection. Here, as will be seen, the plan or top view of the block falls below the bottom of the front elevation while if the drawing were in third-angle projection the plan would be directly *over* the top, where it logically belongs for general convenience as already stated.

THIRD-ANGLE PROJECTION

Geometrical planes are of course imaginary in their character and although for practical purposes we assign them length and breadth they have no thickness. It is therefore sometimes difficult for the practical man to appreciate their significance in the way that he does understand the reality of, say, sheets of metal, paper, etc. In considering first-angle projection the principle of the planes may be more readily grasped if one will consider them as composed of a sheet of paper folded along the ground line *AA'*, Fig. 50, to bring the vertical and horizontal planes at an angle of 90 degrees to each other. Or these planes may be considered like a drawing board hinged along the axis *AA'*. As the object to be drawn is supposed to come between the observer and the planes it is immaterial as to what physical character may be given the planes. But when we deal with third-angle projection we must imagine the planes as made of some transparent material such as glass, for here the plane stands between the object to be drawn and the eye. If we were to prepare a square of glass, something like the background of a camera so that we could see the object behind it and draw upon its surface the outlines of the object we should be enabled to grasp quickly the principles of third-angle projection.

For illustration see Fig. 52. Here we have another simple block with a shallow groove cut across its surface. If we place the glass plate above the block as illustrated in the engraving we see the top of the object and if we place the glass directly upon the block we can draw the plan view as indicated.

Now refer to Fig. 53: The arrangement of the horizontal and vertical planes is the same as in Fig. 50 only here the planes are supposed to be of transparent material and the block to be drawn is supposed to be in the 3rd quadrant, as it is to be

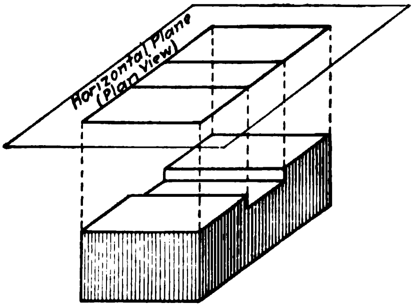


Fig. 52.—View of a Block under a Transparent Plate or Plane.

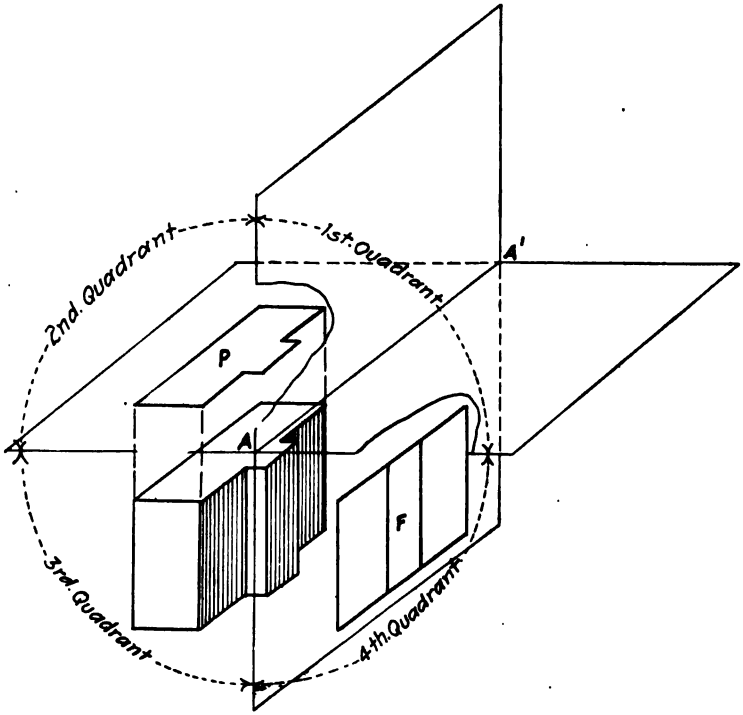


Fig. 53.—Geometrical Arrangement of Views in Third-Angle Projection.

drawn in third-angle projection. Thus we might draw on the horizontal plane at *P* the plan or top view of the work and on the vertical plane at *F* the front view or front elevation just as both appear as seen through the transparent planes. The portion of the vertical and horizontal planes forming the 1st-quadrant are of no significance in connection with third-angle projection and are merely included in Fig. 53 to fill out the complete series of four quadrants. By referring now to Fig. 54 we can see with less liability of confusion the relation between the object which we are supposed to draw and the transparent planes which form the 3rd-quadrant. Projecting the lines from the corners of the supposed object as shown by the dotted lines gives us the plan view *P′* on the horizontal plane and the front elevation *F′* on the vertical plane. Swinging the vertical plane about the axis *AA′* to coincide with the horizontal plane as in Fig. 55 would place the two views in the respective positions illustrated in that engraving.

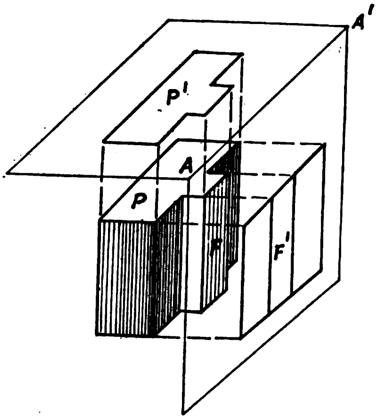


Fig. 54.—Imaginary Position of Work and Planes in Third-Angle Projection.

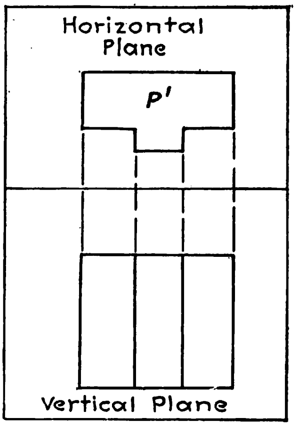


Fig. 55.—Views as They Appear on the Drawing in Third-Angle Projection.

THE GLASS BOX EXPLANATION

In teaching drawing the author has often found it advantageous to explain third-angle projection by asking the pupil to imagine a piece to be drawn as placed inside a glass box such as a tool chest for example, having glass top, sides and ends. See Fig. 56. Now if we were to look down upon the piece to be drawn we would see the plan through the cover of the box and the front elevation through the front wall. If a plan view were actually drawn on the transparent cover and a front view or elevation on the front transparent surface of the box, the cover could then be swung open upon 90 degrees; its hinge *AA′* and the two views would assume the positions shown in Fig. 57. The fine dotted lines in Fig. 56 represent some of the projection lines which establish the outlines of the work in plan and elevation.

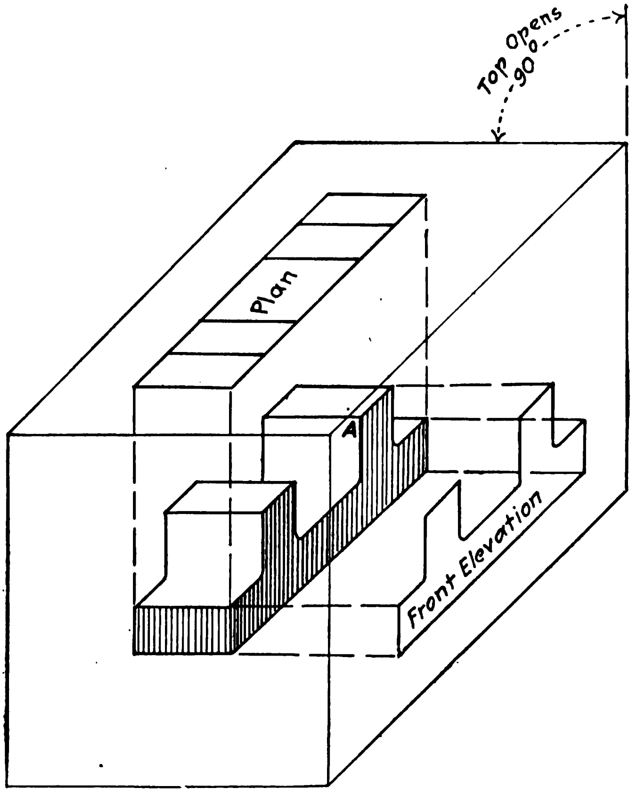


Fig. 56.—Piece Supposed to be Drawn as Placed in a Transparent Box.

Fig. 58 illustrates the glass box idea where three views are desired. In this case besides the plan and front elevation we wish to include a side or end elevation, which would be the projection of the side or end of the object upon the end wall

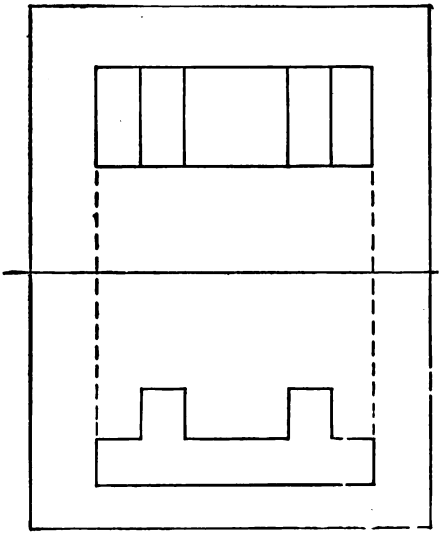


FIG. 57.—Plan and Elevation of Object in Fig. 56.

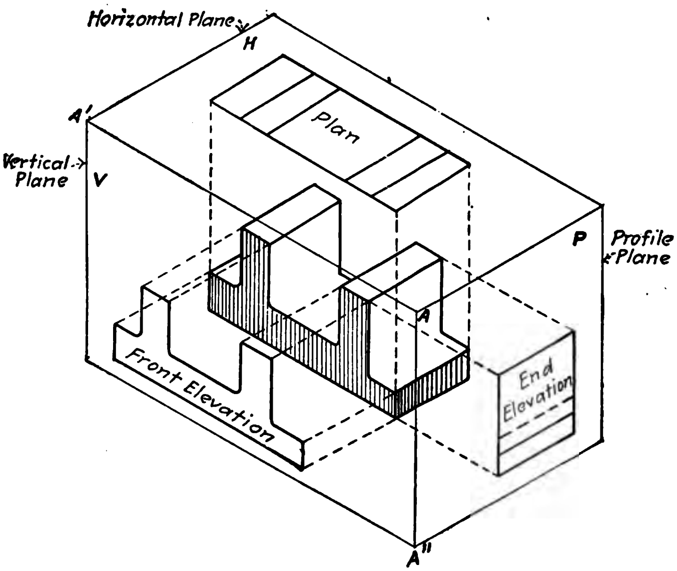


FIG. 58.—Three Views of an Object in a Transparent Box.

of the transparent box. The dotted lines are in sufficient number to show clearly the idea in reference to all views. Now if we were to open the box along hinge line *AA'* to 90 degrees and similarly along corner line *AA"* (assuming the latter to be hinged also) we would bring the three views into the position shown by Fig. 59. Both front and end elevations are in vertical planes. The end or side elevation plane is sometimes called the profile plane though in mechanical drawing it more commonly is known simply as a vertical plane.

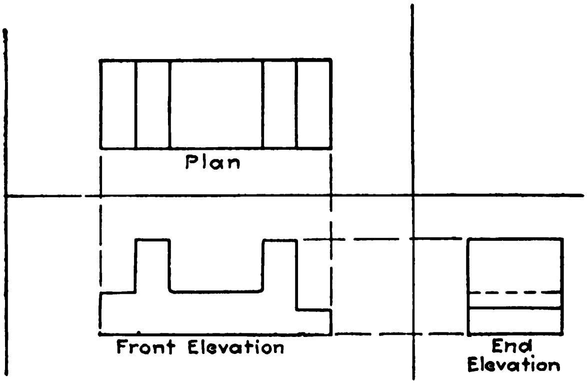


FIG. 59.—Arrangement of Drawing Views of Object Shown in Fig. 58.

THE PROJECTIONS OF A STEEL SQUARE

A simple piece of work for practice in projection is the drawing of a toolmaker's square as in Fig. 60. If the student has a square he may measure the side dimensions of stock and blade and lay out the side view as shown. Then by taking the end of the blade in the fingers he may draw it upward and away from him and at the same time tip it upright upon its stock, thus as he looks down upon its end he has the plan before him and can draw this directly over the side view. For this plan he needs only the thickness of blade and stock as the other dimensions may be transferred to the plan by projecting through dotted lines as indicated to give length of stock, width of blade and offset of blade from the end of the stock. He may then move the square to the right, revolve it through 90 degrees as indicated by dotted lines *R*, slide it down opposite the side view and tip it up on the outer end of the stock. In this position the front edge of the blade is toward him and he can now draw the front view. The actual thickness and height of blade and stock can be taken from the other views already drawn. The dotted lines show the projections from one view to another. In actual practice the dotted arcs at *R* representing the 90 degree turn would not be made at all but by turning in this way from the plan to the elevation the student soon acquires familiarity with the principle involved in projection.

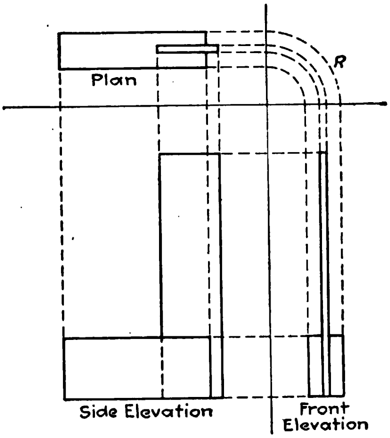


FIG. 60.—Projections of a Steel Square.

LINES AT AN ANGLE TO THE PLANES

Frequently one or more lines or faces of a casting or forging drawing may be at an angle with one or more planes of projection so that the true length or proportions are not shown in the different views. If the line is parallel to any plane its length will be shown correctly in the projection on that plane. Where it is essential that the true length of a slanting line or sloping face be shown by one or more of its projections it may be necessary to add what is known as an auxiliary view which is made on a plane parallel to the line or surface in question.

Considering for a moment the true length of a line, refer to Fig. 61. Disregarding for the present the matter of first and third angle projection, let us imagine that we hold a straight object, say a lead pencil, at an angle to both the horizontal and vertical planes of projection. If lines *aa'* are dropped from the pencil ends upon the horizontal plane the connecting line *L* representing the horizontal projection of the pencil will obviously be shorter than the pencil itself. Similarly, if lines *bb'* are projected from the ends horizontally to the vertical plane *V* the line L' representing the pencil in that plane will also be too short. We must therefore swing the pencil around until it is parallel to one of the planes. Now in Fig. 62 which is the same view as Fig. 61, except that it is not in perspective, the line *L* is swung about its end until it comes parallel to vertical

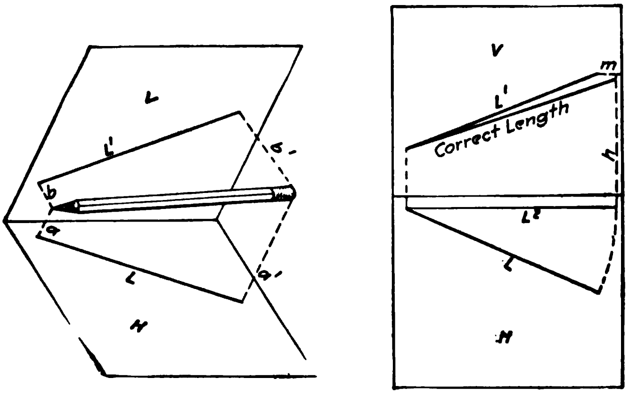


FIG. 61 FIG. 62

True Length of a Line.

plane *V* as indicated by *L2.* Its angular position in reference to plane *H* remains unchanged however, that is heights *a* and *a'* (Fig. 61) are the same as before the pencil was swung around. But as the pencil is now parallel to vertical plane *V* its true length can be projected upon that plane although it will still show as a slanting line. The original projection on the vertical plane is at L'. So from the end of the new projection L^2 on the horizontal plane we carry a line *h* up on the vertical plane until it intersects a horizontal line *m* extending from the top of line L'. A new line is then drawn from the point of intersection to the lower end of line L' and this is the true length of line.

Again imagine we are holding a triangle Fig. 63 upright on its edge on the drawing board and that its base line length is shown at *B*, Figs. 63 and 64. If we imagine a vertical plane of projection at *V* or if we use the ground line *A-A′* as the base of that plane, we know that the base line of the triangle as projected on the plane at *B′* will be shorter than *B* on the horizontal plane on account of the angular relation between the face of the triangle and the plane *V*. Now assume that we wish to project the triangle in such manner as to show the true length of side *h* representing the hypotenuse, which is of course at an angle to both planes of projection. The first thing is to consider that we swing the triangle about its point as in Fig.

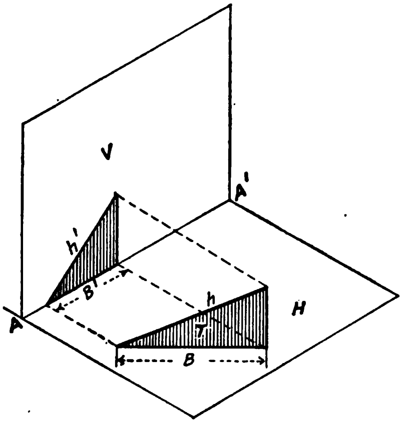


FIG. 63

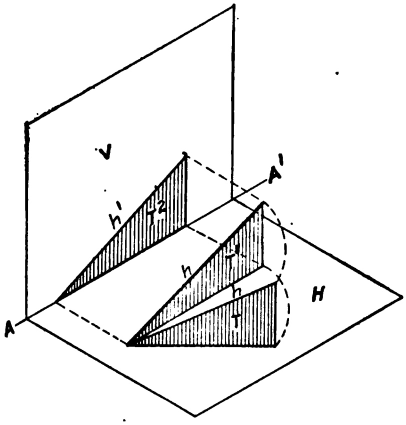


FIG. 65

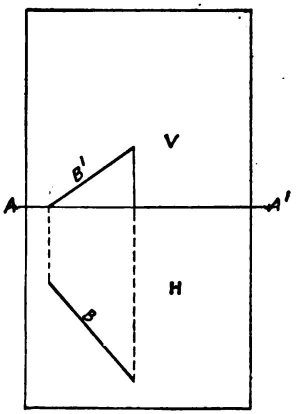


FIG. 64

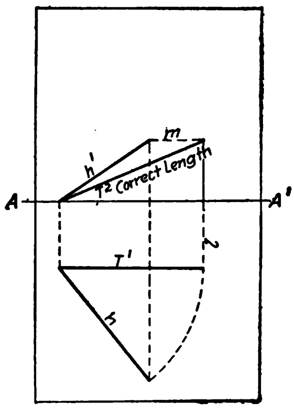


FIG. 66

True Length of a Line.

65 until its face is parallel to plane *V*. That is, it is supposed to be swung from position *T* to *T′*, then it may be projected exactly at T^2 upon the vertical plane *V*. Referring to Fig. 66 we see the original projection of edge *h* in the horizontal plane and the same edge at *h′* on the vertical plane. When we swing or revolve the triangle about its point we move it to *T′* on the horizontal plane and the projection of this line onto the vertical plane is accomplished by extending the projecting line *l* to intersect the line *m* (which is extended from the top of *h′*), and then joining this point of intersection to the lower end of line *h′*, giving the true length of line T^2.

PRACTICAL APPLICATIONS WITH TRUE LENGTHS OF LINES

A line at right angles to or perpendicular to a plane is projected as a dot or point upon that plane. If the line is parallel to that plane its projection upon the plane is the true length of the line. If the line is at an angle with the plane its length as projected upon that plane is necessarily somewhere between a point and the full length of the line itself. This has been shown in the preceding examples, where the projections were of lines at angles to both planes of projection.

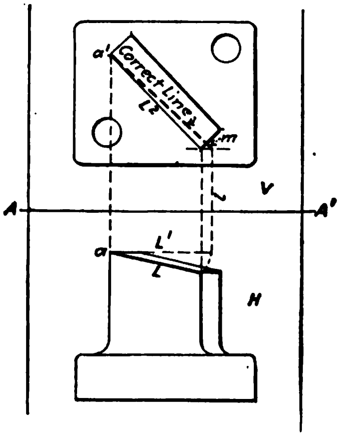


Fig. 67.—Practical Illustration of Finding of True Length of Line.

Now taking a practical case under consideration, let us refer to Fig. 67 which shows a special form of tool block, the upper portion of which is at an angle crosswise of the base while the top edge is inclined to the bottom of the base. If we wish to know the true length of line *L* in order to machine some part to fit this exactly we could not get it by scaling either of the views on the horizontal or vertical projection, for in neither projection is the true length of line shown by the original drawing. However by revolving line *L* about its upper end *a* until it lies parallel to ground line *AA*, (as at *L'*) we can then extend a line *l* upward to intersect line *m* on the vertical plane which is drawn horizontally from the lower end of L^2 which is the vertical projection of the original line *L*. We then draw a line from *a'* to *m* and thus secure the true length of the line.

However, wherever the shop is required to know the length of a given line which is in an angular position or the exact dimensions of a surface not parallel to the planes of projection, it is incumbent upon the draftsman to lay out an auxiliary view upon an auxiliary plane. Thus in Fig. 68 which shows a case closely similar to Fig. 67 three views are given at *H, V* and *P* in none of which is seen the correct length of line *B*. For as will be observed, this face of the piece is in an angular position in relation to all three planes of projection. Consequently an auxiliary view is required as at *W* which represents the situation if we imagine plan view *H* to be revolved about an auxiliary ground line *A2, A3,* which is drawn parallel to face *B* in that view. Thus the width of face *B* is given at once upon the auxiliary view *W* and the heights at the corners *h* and *h'* for that view are correctly obtained directly from the vertical projections of these corners on plane *V*.

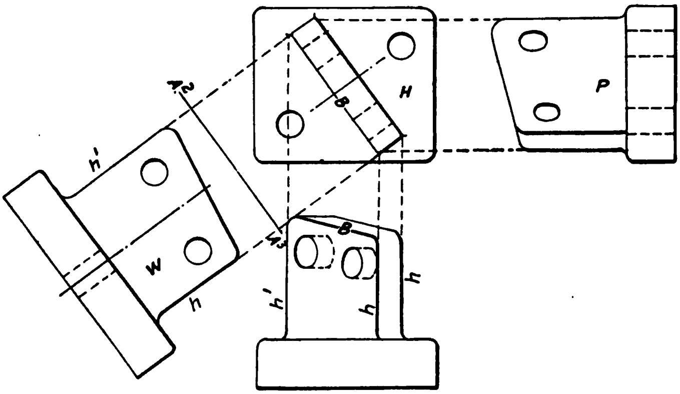


FIG. 68.—Showing Auxiliary View for Giving True Length of Line.

SIMPLE AUXILIARY VIEWS

Very common applications of auxiliary views are found in such cases as Figs. 69, 70 and 71. The first of these illustrations shows a square block cut off at an angle at one end. In plan *P* lines *t* and *b* represent the top and bottom of the block at the beveled end while in front elevation *F* we see the true length of sloping line *s* which is the edge formed by the angular cut.

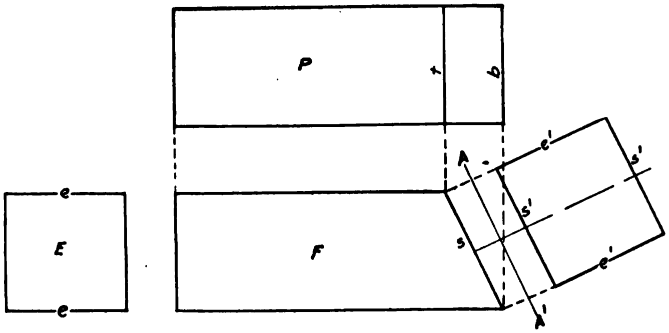


Fig. 69.—Auxiliary View of Square Section Cut at an Angle.

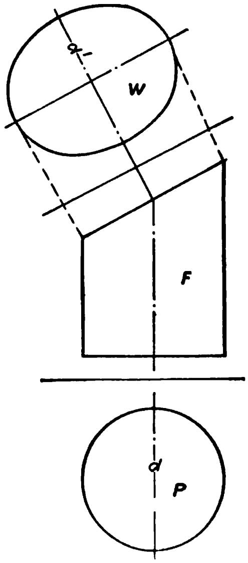


Fig. 70.—Auxiliary View of a Cylinder Cut at an Angle.

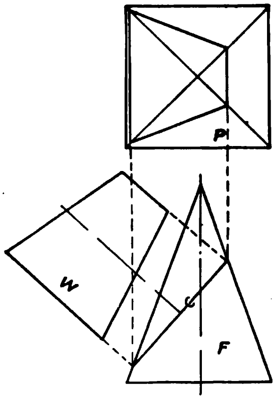


Fig. 71.—Auxiliary View of a Square Pyramid Cut at an Angle.

End view *E* shows the square shape of the block. To show the exact form of the angular surface at the other end we draw an auxiliary view *W* which is in a plane supposed to be swung about ground line *AA′* which is of course parallel to sloping edge *s*. Lines *s′s′* are equal in length to the slanting line *s* and lines *e′e′* are obviously equal to lines *ee* of the end view. The figure enclosed in lines *s′s′* and *e′e′* is therefore not a square but a rectangle as indicated.

In Fig. 70 we have a similar auxiliary view of a round piece or cylinder *F*, which is cut off at an angle at the top. The plan *P* of this cylinder is a circle but the auxiliary view *W* of the sloping upper face of this cylinder is seen to be an ellipse. While the short diameter of this ellipse *d′* is always the same as the diameter *d* of the cylinder, the long diameter or major axis of the ellipse depends upon the angle to which the cylinder is cut.

Fig. 71 shows a pyramid with square base and with a sloping cut *c* made across the body, as seen in elevation *F*. The auxiliary view *W* shows the exact shape of the face *c* when projected on a plane perpendicular to line *c*.

USE OF SECTIONS IN PROJECTIONS

Frequently in making drawings one or more views are best shown as sections in order to represent the interior more clearly or to bring out some detail more clearly than would be possible if all views were external. Thus, Figs. 72 to 75 show various ways of representing a bushing or sleeve in which there is a chamber of recess. In Fig. 72 the longitudinal view is shown as a longitudinal section just as the bushing would appear if split lengthwise along the center line. While this longitudinal or side view could be drawn as an external projection the internal chamber would have to be shown by dotted lines and the bore in the same manner. If there were many outside lines as with the head of the bushing and as there might be if the outside of the body were machined otherwise than as a straight cylinder, there would be ample opportunity for confusion and possibility of error in making the piece in the metal. With the sectional view shown there is no chance of misunderstanding upon the part of the man who uses the drawing.

Another way of showing such a part clearly is by a partial section as in Fig. 73. In this instance the longitudinal view is supposed to be cut away for a quarter of the circumference and the section shows only the interior of the upper half of the bushing. This method allows the outside proportions of the head to be clearly seen, at the same time giving a distinct view of the interior.

In Fig. 74 the longitudinal or side elevation is drawn up as an outside view but the plan or end elevation is in section. This is marked "Cross-section on line *a-b*." This not only shows the recessed chamber in the bushing so far as depth is concerned but also gives a clear idea of the thickness of metal in the wall of the bushing as compared with the rest of the piece. Frequently a section of this kind is of benefit to the designer and draftsman in enabling just such a comparison to be made when determining proportions of walls and the like.

FIG. 72

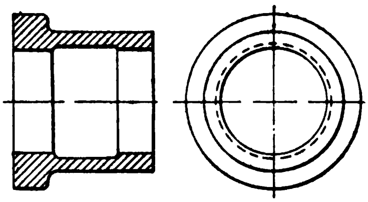
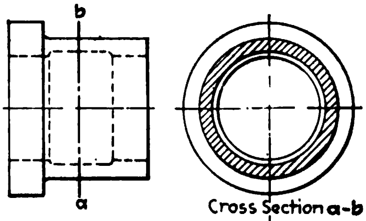


FIG. 74



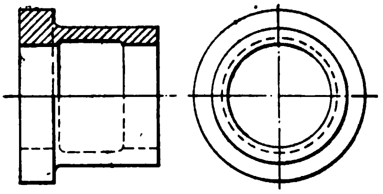


FIG. 73

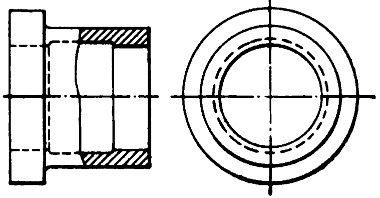


FIG. 75

FIG. 72.—Longitudinal Section.
FIG. 73.—Partial Longitudinal Section.
FIG. 74.—Full Elevation and Cross-section.
FIG. 75.—Broken Section.

The broken section, Fig. 75, is a favorite method of showing both outside and inside of certain classes of details. It is used more commonly than the others on many kinds of work. It gives at once the form of the inside of the work and leads the eye to follow accurately any portions of the piece that may still be concealed by the unbroken portion, and thus the whole interior is readily understood without the necessity of sacrificing on the drawing all of the exterior surface some part of which may be of importance when the drawing is to be interpreted. Furthermore, the broken section is easily made and much time is saved over the method where a complete section is made and its entire area cross hatched.

A neat example of a full longitudinal section is presented in Fig. 76. This shows a spindle operated in ball bearings.

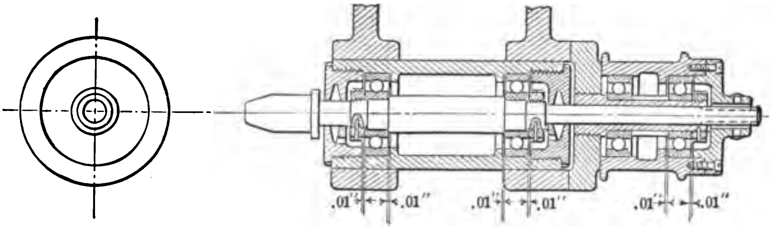


Fig. 76.—Longitudinal Section through Spindle and Bearings.

In this case the spindle is shown from the outside as its internal dimensions are not required. But all other members are shown in section and cross hatched as indicated.

SEVERAL VIEWS OFTEN NECESSARY

While the illustrations referred to above have only two views in each case, it is oftentimes desirable to show three or more views in drawings where other than simple parts are represented. In fact the majority of drawings except of simple details are made up of at least three views, that is, plan, front elevation, and end or side elevation. Usually where other views are required one or more is a cross-section or longitudinal section.

In Fig. 77 is shown a gasoline motor with one cylinder cut open to allow the piston to be seen. This cylinder is water jacketed as indicated and the system of water openings and connections makes it desirable to show a number of views in the drawing in order that the interior openings may be clearly defined for the pattern maker. Such a cylinder is well represented by the views in Fig. 78. Here in addition to plan and front elevation there is a cross-section as made with a plane cutting through the cylinder square with the axis; and a vertical section as the cylinder would appear if split along its axis or center line.

Similarly with the cylinder head Fig. 79. The projections of this as actually drawn are seen in Fig. 80. Besides plan and front elevation, there is a section through the center of the head and at the right of this the head is represented as turned bottom side up and a plan is drawn of the bottom of the head. This latter view shows clearly the water openings and the valve seats in the lower face.

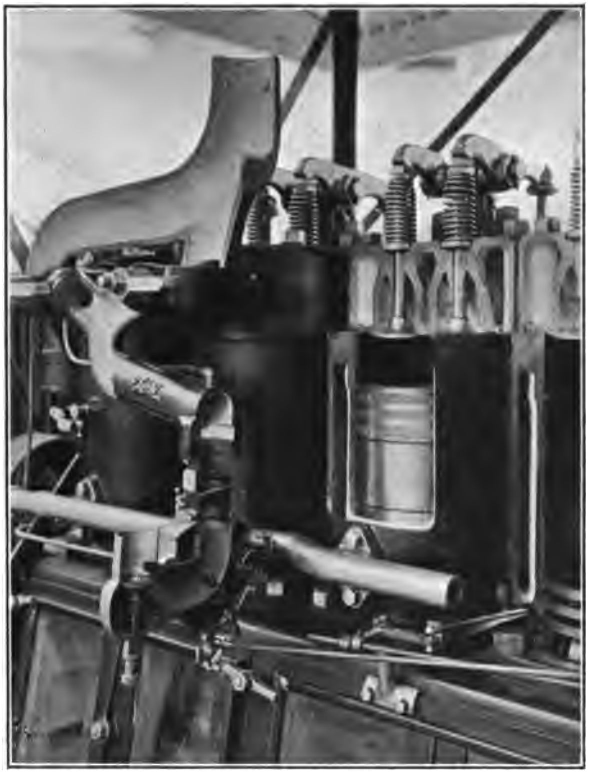


FIG. 77.—Motor Cylinder for Tractor.

THE USE OF SHADE LINES

Shade lines on drawings while used only occasionally in the drawing room help greatly to a correct reading of the different views and frequently make it possible to dispense with certain views that would be required otherwise. Shade lines refer here not to surface shading as commonly understood but to the use of heavy and light lines on definite parts of the drawing to distinguish openings and depressed portions from solid surfaces, bosses and other raised portions. Thus in Fig. 81 a casting is represented shown in three views, plan, front elevation and cross-section. The location of the heavy lines known as shade lines is determined by considering that the light is directed from the upper left hand corner of the

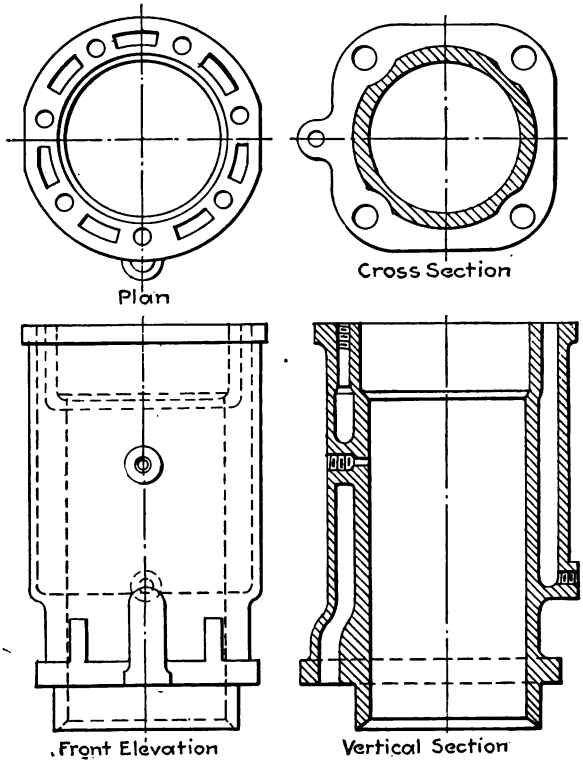


FIG. 78.—Cylinder for Gasoline Motor.

view as indicated by the arrow. The light is supposed to fall at an angle of about 45 degrees and the upper and left hand lines of the views are therefore in the light and represented by the light line of normal width. The lower and right hand edges of the drawing are considered as in the shade and are shown by heavy lines. Similarly with bosses, etc., the upper and left hand sides are in the path of the light as represented and drawn in normal width of lines while the lower and right

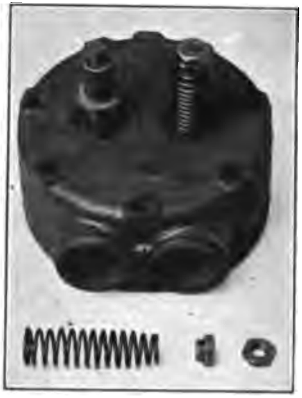
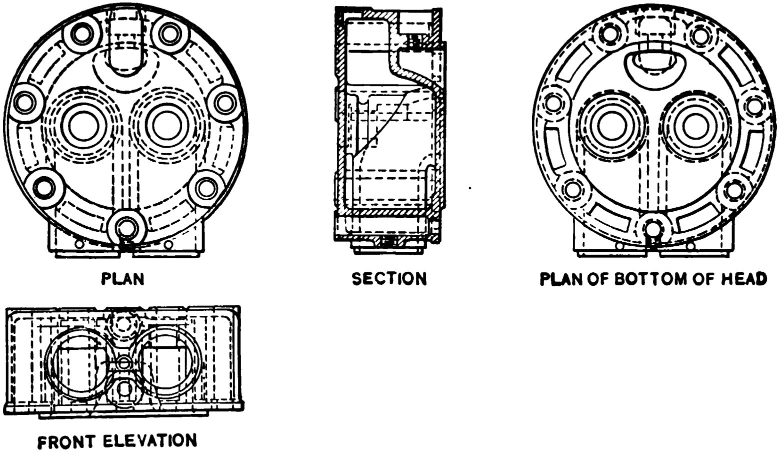


Fig. 79.—Cylinder Head.



PLAN

SECTION

PLAN OF BOTTOM OF HEAD

FRONT ELEVATION

Fig. 80.—Arrangement of Views of Cylinder Head.

hand sides of these bosses are shaded or obscured and consequently are shown by the heavy shade line. Openings and depressions are represented by heavy lines at the top and along the left side while the lower and right side of the opening is shown in light or normal width of line. By studying the direction of the light and the manner in which the different edges are exposed to the light, or shadowed as the case may be the reader will grasp the principle of shade line application.

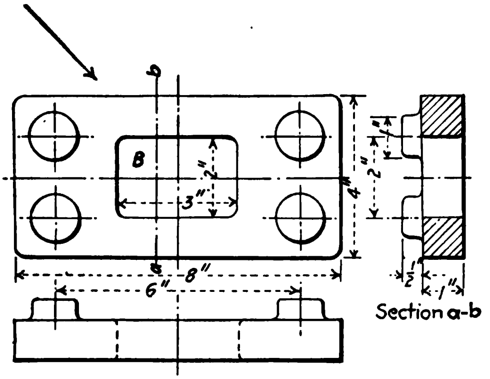


Fig. 81.—The Use of Shade Lines.

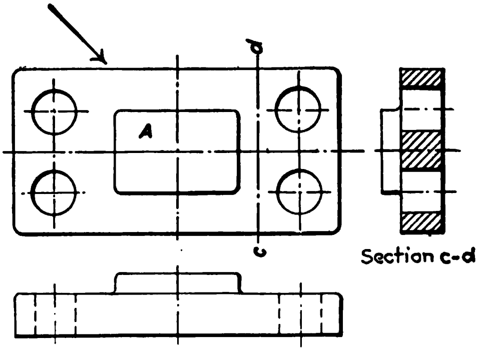


Fig. 82.—The Use of Shade Lines.

Reference to Fig. 82 and comparison of this with Fig. 81 shows that the rectangular boss *A* on the former is shaded on the right and lower sides while the opening *B* of similar form in Fig. 81 is shaded on the upper and left side. Compare also the round bosses in Fig. 81 with the round holes in Fig. 82.

Now the use of shade lines enables a single view to answer many times for a complete drawing although as pointed out before, it is usually preferable to show two or more views. However, with simple work the single view is often satisfactory. Thus Fig. 83 shows a plan view similar to the plan in Fig. 81. In Fig. 83 shade lines are employed and these with the dimensions and the notes "Boss ½ inch high" and "Plate 1 inch thick" convey all the information actually necessary for the making of the piece in the shop.

Similarly the shade lines and notation on Fig. 84 (which corresponds to the plan view in Fig. 82) show the true form and proportions of the plate in Fig. 84 with its raised pad and four 1-inch holes.

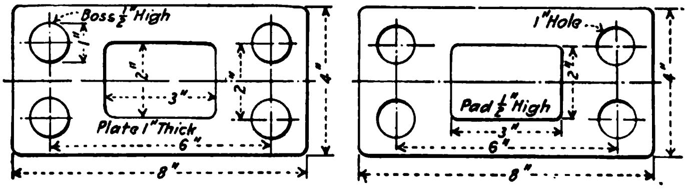


Fig. 83 Fig. 84

Shade Lines on Single Views.

SECTION LINING OR CROSS HATCHING

A number of illustrations in this chapter show sections of various objects with the section "cross hatched" that is, filled in with slanting lines which distinguish the section from outside views. Reference to the different sections in the chapter will show that the section lining or cross hatching is usually done in a fairly fine line and at an angle of 45 degrees. Usually the lines are spaced from $^3/_{64}$ to $^1/_{16}$ inch apart, though on large sections they are somewhat more widely spaced. Where a number of parts adjoining one another are sectioned they are often spaced at different widths for the sake of clearness and sometimes one or more parts are shown by lines at 60 degrees instead of all being at 45. In Fig. 76 an excellent example of clear section lining is reproduced and the student will do well to give this drawing some little attention.

The spacing of the triangle along the T-square in section lining (see Fig. 13) is usually done by the eye without special device of any kind for accuracy of space. Such appliances have been made in considerable numbers but ordinarily the draftsman soon acquires such skill in quick and accurate manipulation of the triangle along the T-square blade that he does not care to make use of a special tool for the purpose.

CHAPTER III

PRACTICAL APPLICATIONS OF THE PRINCIPLES OF PROJECTION

In this chapter a number of drawings are reproduced in which plan and elevations are shown as duplicates of photographic views of the same objects. That is, as in Figs. 85 and 86, two photographic views are first presented of a given piece, (Fig. 85), which is followed by two similar views as actually drawn and dimensioned (Fig. 86). Thus the student has before him at the outset a photographic representation of the object as it would actually appear to the eye when seen in both plan and front or side elevation, and further he has the corresponding views as actually drawn on the board. A few dimensions are given on the photographs and complete dimensions on the drawings. Both sets of views are marked "f" on certain surfaces. This "f" indicates that all surfaces so marked are to be finished. Under this method of examining first the "picture" of the object and then studying the line drawings of corresponding projections it should be an easy matter for the student to learn to fix in mind the "picture" of any piece of work which is yet to be built and then put down on the drawing board the necessary projections or views for forming a practical working drawing of the piece from which it can be readily made in the shop.

Refer now to Fig. 85: we have here the picture of a short bushing. In the plan "picture" this bushing resembles a ring with thick walls. In the front elevation the outline is a rectangle. The shaded effect of the photographic print shows that the piece is cylindrical but we do not know that it is bored through from end to end to form a bushing unless we examine the plan view and see the hole through the center. In Fig. 86 if we were to shade the surface of the elevation *F* we could make the cylindrical character of the piece apparent at once, but as a rule surface shading is not as desirable as an additional view and so we show the plan view *P* which reveals the fact immediately that the piece is a hollow ring or bushing. Surface shading is however used effectively upon occasion and this treatment of certain classes of drawings will be touched upon in a later chapter.

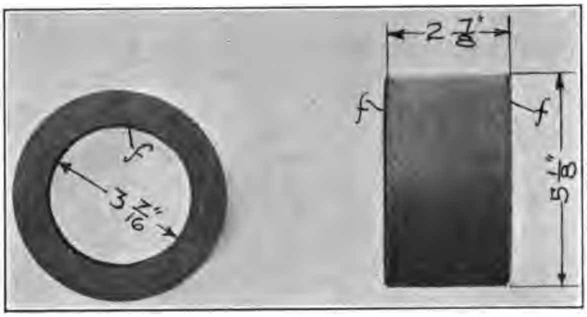


FIG. 85.—Plain Bushing.

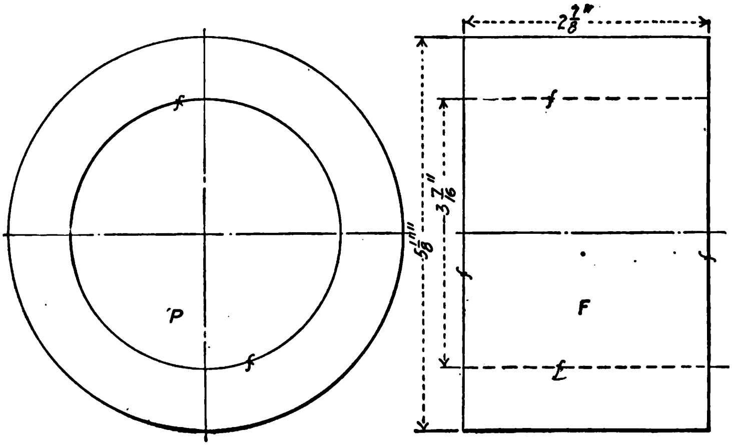


FIG. 86.—Drawing of Bushing Shown in Fig. 85.

DRAWING THE BUSHING

Now for actual practice, draw the plan of this bushing and then make an elevation like Fig. 86. As this is a fairly small piece of work draw the bushing full size in accordance with the dimensions shown. After this draw it to a scale of 6 inches equal 1 foot, or one half size. Then draw it to quarter size or to a scale of 3 in. equal 1 ft. Use the draftsman's scale, selecting the required corner for the given scale. If it is to be quarter size this is 3 in. to 1 ft. and the scale is placed with the required corner on the drawing. Each inch on that corner is actually only 1/4 inch long and a foot is only 3 inches long as represented by that particular scale. Practice with the different scales will soon lead to familiarity in reading the proportionate parts on the rule. And it is then just as easy to lay off a line which, while representing a length of piece of say 8 inches is actually only 4 inches (half size) or 2 inches (quarter size) as it would be to make the line actually 8 inches long (or full size). For on the "3 in. to 1 ft." corner of the scale each *quarter inch* is marked as an *even inch* and its subdivisions represent to one-quarter size the subdivisions of the even inch. And so on with other scales.

The drawings shown in this and other chapters are reproduced from prominent manufacturers shop blue prints and each is a practical working drawing. Hence the student following these instructions and making similar drawings to various scales is familiarizing himself with important features of the practical work of various conspicuous drawing offices. As already explained, the photographs are included here to enable the reader to grasp more quickly the relation between a piece of work as seen by the eye and the various mechanical views required to assure the piece being properly made in the shop.

A BRONZE BEARING

In Figs. 87 and 88 is shown a bronze bearing which in the photographic views, Fig. 87, is seen in plan and elevation while similar views as actually drawn are presented in Fig. 88 with the addition of certain dotted lines that show the interior bore with its oil channels. Draw this full size and then change the general dimensions and make a drawing to the new dimensions. The photographs will serve as a definite aid in the process of selecting suitable dimensions and redrawing the bearing in plan and elevation as they will help to the retaining in the mind of the actual appearance of such a bearing when completed in the shop.

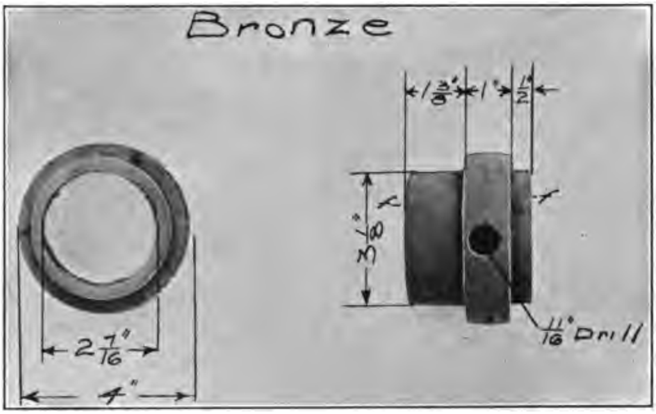


FIG. 87.—Bronze Bushing.

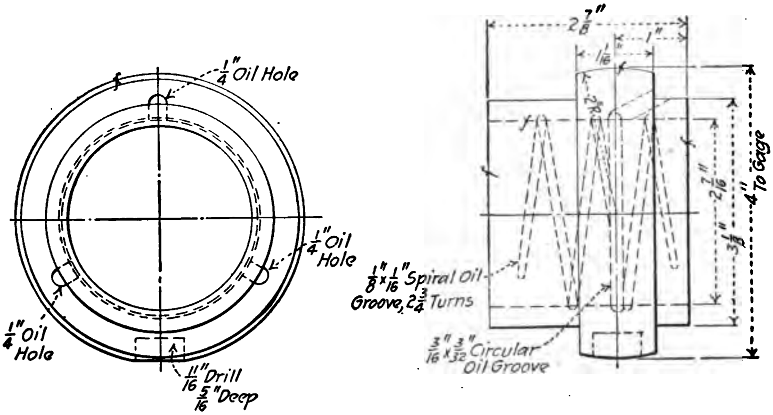


FIG. 88.—Drawing of Bronze Bushing Shown in Fig. 87.

ROLLER WITH LONG HUB

The roller in Figs. 89 and 90 has a long hub and the latter is bored to $1^1/_{16}$ inch diameter. Note the tapered hubs and the recessed face of the disk portion of the casting. Draw this piece full size or half size according to preference and size of paper used. It is always well in drawing the various pieces illustrated here to use a scale of half or quarter size in order to gain practice in the use of the scale.

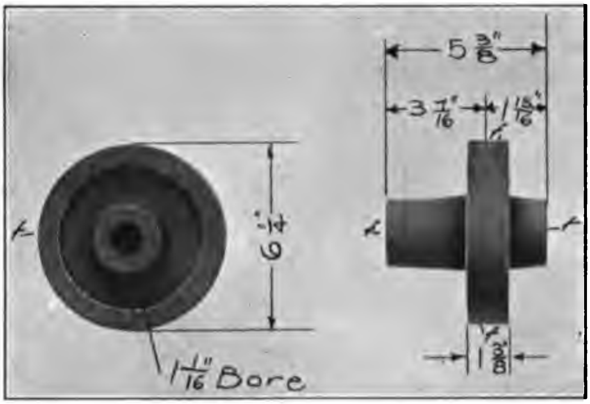


Fig. 89.—A Roller

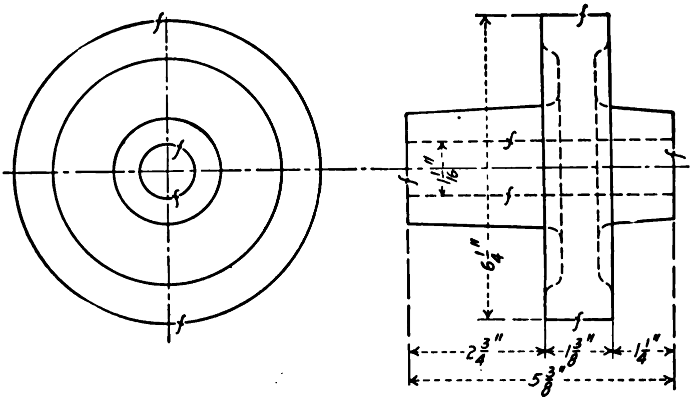


Fig. 90.—Drawing of Roller Shown in Fig. 89.

A SPRING CAP

The cap in Fig. 91 is for acting upon a spring. The square body of the piece is recessed to the form of a hemisphere and the hub is bored to 3/4 inch. Note the tapered or beveled sides of the base from the center of the body to the outer face.

FRICTION PARTS

Figs. 93 and 94 are views and drawing of a female friction disk and Figs. 95 and 96 show a female friction inner disk.

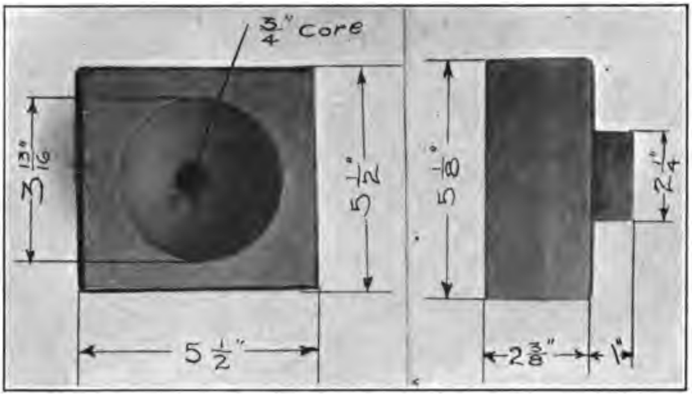


FIG. 91.—A Spring Cap.

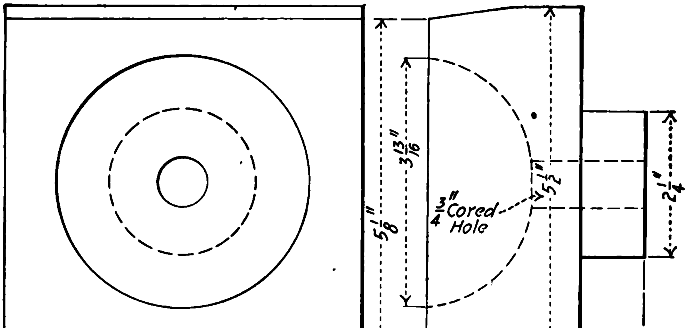


FIG. 92.—Drawing of Cap Shown in Fig. 91.

Figs. 97 and 98 show a male friction to correspond with the set in the former illustrations. All of these friction members form excellent examples of detail drawing work and should aid the student in his practice and help toward a clear understanding of projection and of its application in the making of practical drawings.

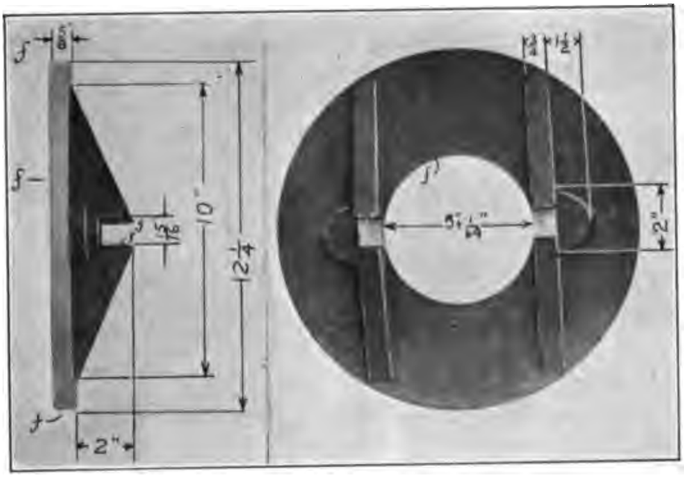


Fig. 93.—Friction Disk.

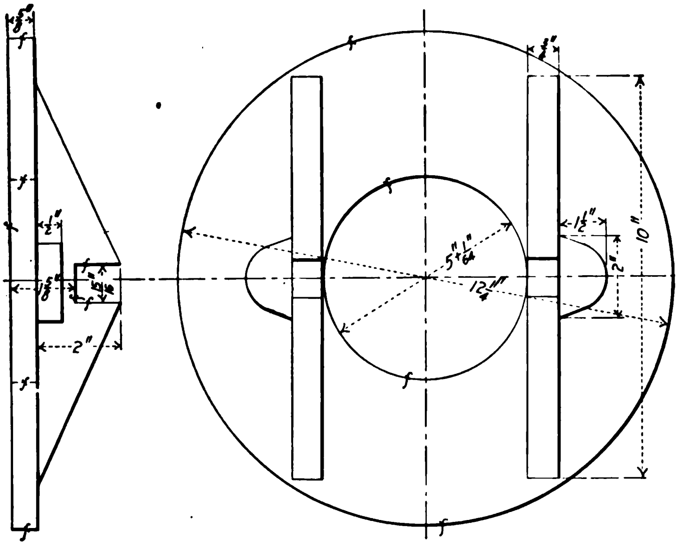


Fig. 94.—Drawing of Friction Disk Shown in Fig. 93.

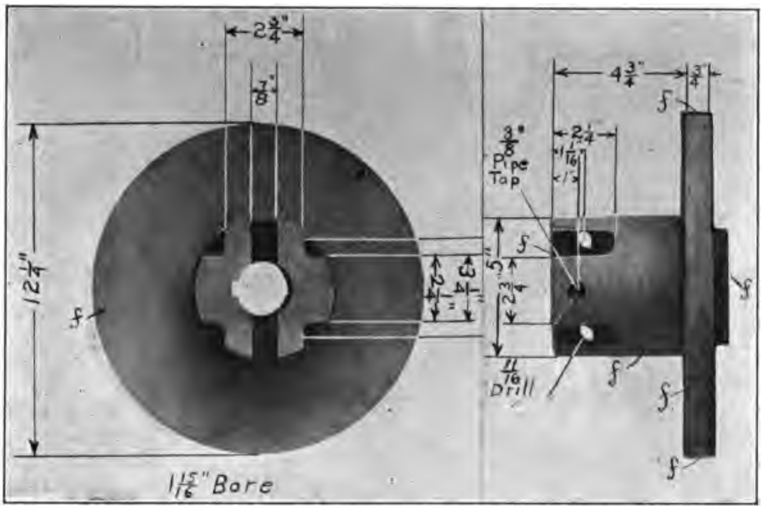


FIG. 95.—Friction Hub Plate.

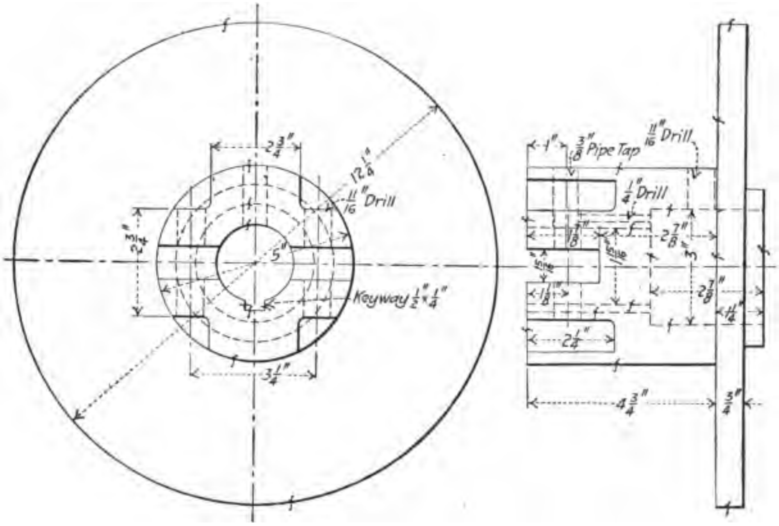


FIG. 96.—Drawing of Friction Hub Plate Shown in Fig. 95.

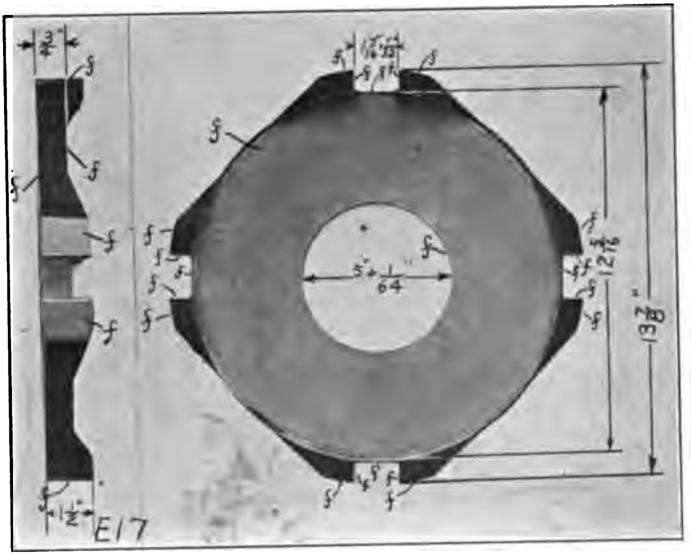


Fig. 97.—Friction Plate.

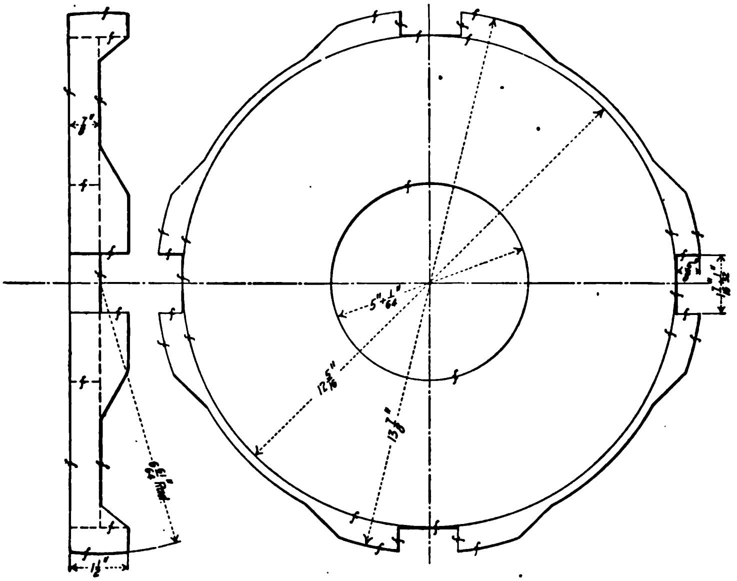


Fig. 98.—Drawing of Friction Plate Shown in Fig. 97.

A SHIFTING LEVER

A different type of piece is shown by Figs. 99 and 100. This is a forked shifting lever with long flat section handle.

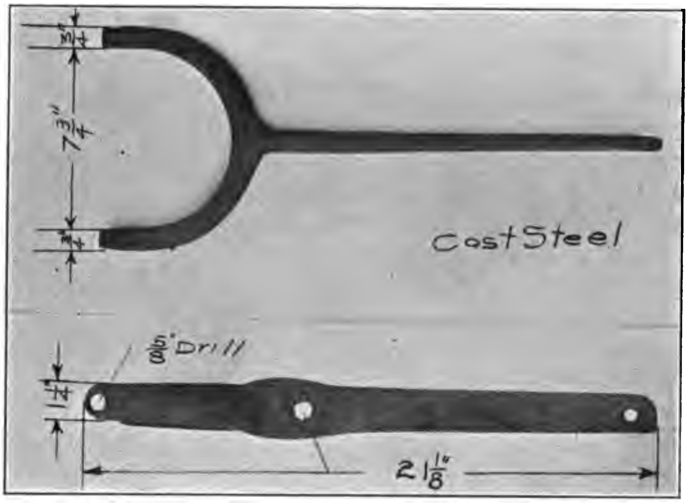


Fig. 99.—Shifting Lever.

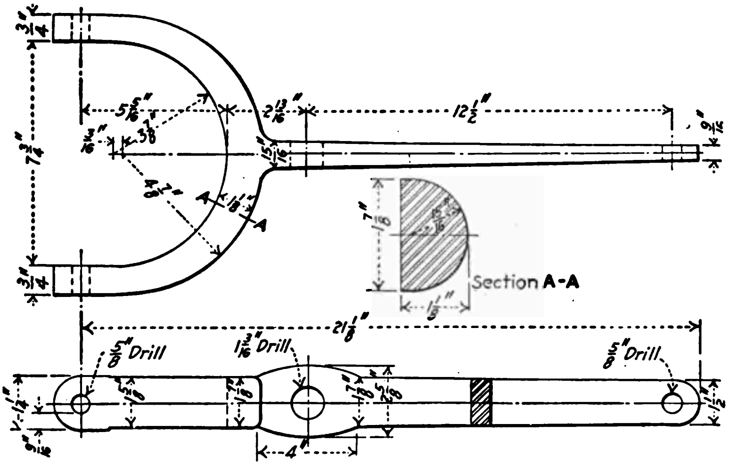


Fig. 100.—Drawing of Shifting Lever, shown in Fig. 99.

Besides the plan and side elevation in Fig. 100 there is a cross-section *AA* through one of the forks showing the true shape of that member as it would appear if cut square across along line *AA*. Also there is a section cut through the handle to show the form of the metal at the point indicated.

OTHER MACHINE MEMBERS

Thus far the machine members illustrated in this chapter have been represented by exactly corresponding views in both photographs and drawings. The illustrations that follow however have been selected on a little different basis in order to give the drawing student wider opportunity for consideration in the arranging of views in the planes of projection. Thus in Fig. 101 the photographic views show a special bearing box in front elevation and side elevation. The corresponding drawing, Fig. 102, shows this box in *plan* and front elevation. Make a drawing showing the plan and front elevation and then add a third view, the side elevation, placing this over the front elevation. The photograph of this side elevation shows the form of the box as seen from the side and it can be readily drawn in above the front elevation.

In Fig. 103 a thrust collar is shown by a photograph of the face or plan of the collar and a photograph of the side view. The drawing of this thrust collar in Fig. 104 shows the same side view but the plan view is of the back face or inner face of the collar. Make this drawing and add a third view, the plan of the outer face as in the photograph, and place this third view at the right of the side view in Fig. 104. It will be understood that this additional plan view is to be on the same center line as the other views in the drawing. The completed drawing will then show on the one horizontal center line a plan of the face of the collar at the right, a side view in the middle of the drawing and a plan of the bottom or back of the collar at the left.

The two bolts, which are seen in Fig. 103, for holding the two parts of the collar together may be omitted from the drawing as we have not as yet reached a study of bolts and nuts.

Figs. 105 and 106 show a long cap for a shaft bearing. Two views are seen in the photograph, and three in the drawing. Make three views as in the drawing. Use care in drawing in the full and dotted portions of the circles forming the bolt bosses.

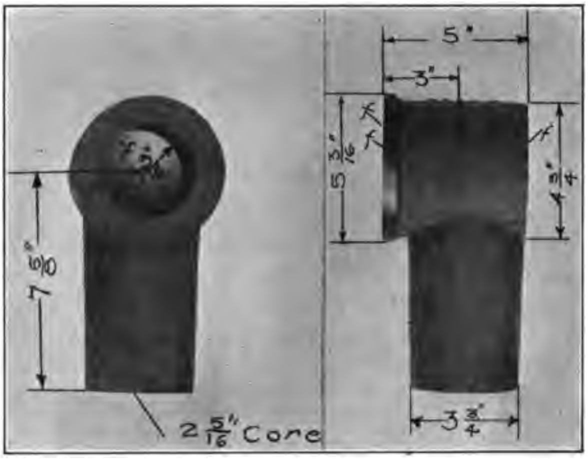


FIG. 101.—Special Box.

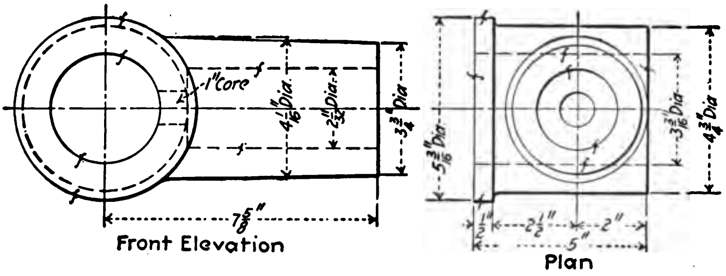


FIG. 102.—Drawing of Special Box Shown in Fig. 101.

SECTIONAL VIEWS

The countershaft box in Fig. 107 is shown in Fig. 108 with the bearing cap in place and there is also a sectional view formed by drawing an end view as it would appear if the upright were to be cut square across on line *AB*. Make a drawing similar to Fig. 108 including section *A-B* and also add a top view of the cap, which should be drawn directly above the cap in the front elevation.

The fly wheel shown by photograph Fig. 109 is drawn in plan and section in Fig. 110. This section it should be noted is along line *A-B* which is along the diameter of the wheel for one half the distance and then continues at an offset along a plane in front of one of the arms. This offsetting of the section-cutting plane enables two different sections to be shown in

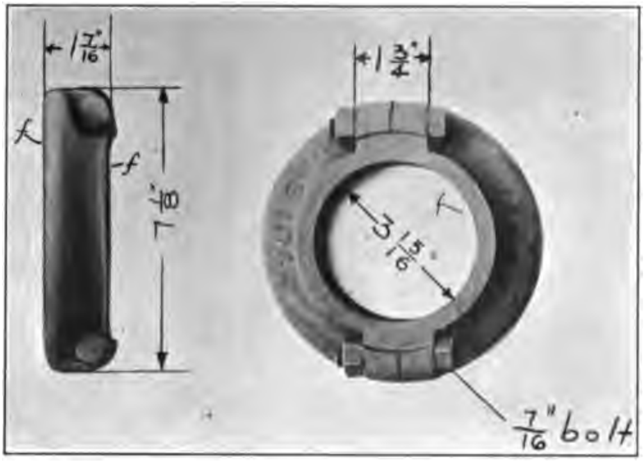


Fig. 103.—Thrust Collar.

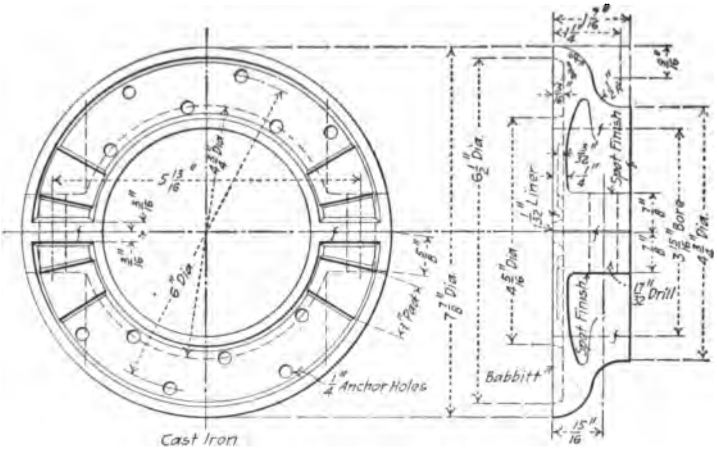


Fig. 104.—Drawing of Thrust Collar Shown in Fig. 103.

the one view. Ordinarily with fly wheels and pulleys in general it is customary to show only a section in front of an arm as in the lower half on the section of Fig. 110. But sometimes where the arms have side ribs as in this case it may also be of service to show a section along the center of an arm as in the upper half of Fig. 110. The sectioning of

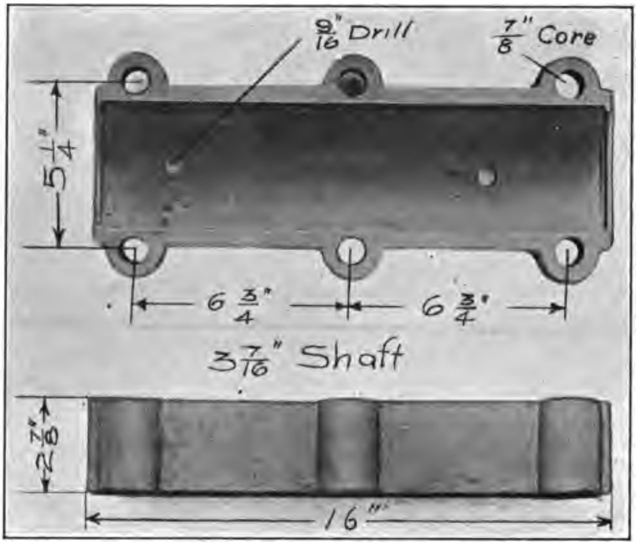


Fig. 105.—Shaft Bearing Cap.

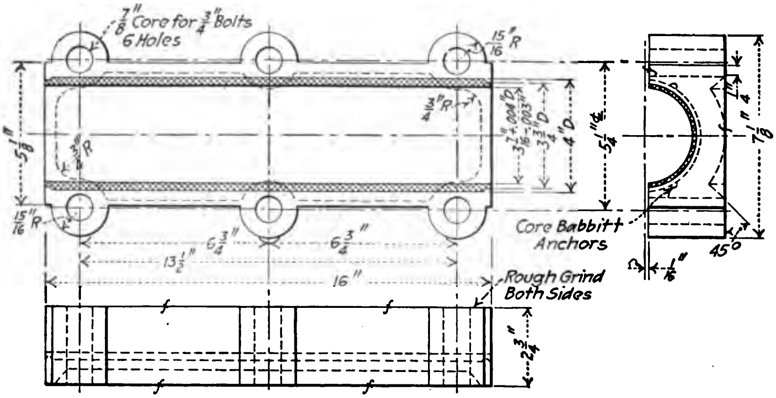


Fig. 106.—Drawing of Cap Shown in Fig. 105.

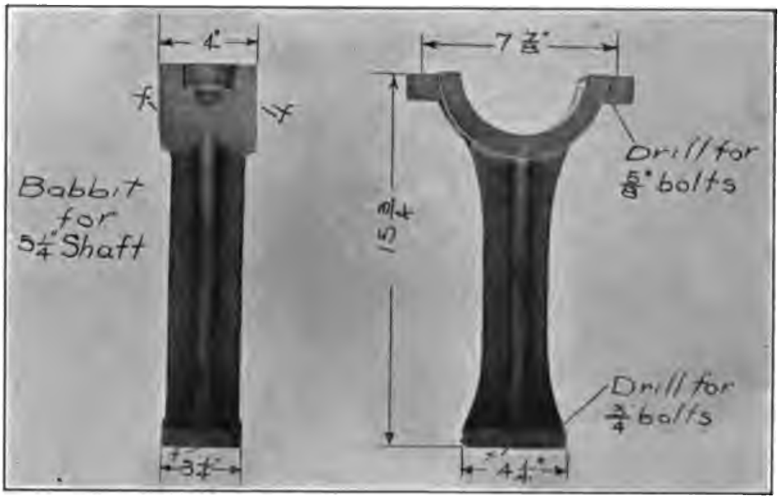


FIG. 107.—Countershaft Box.

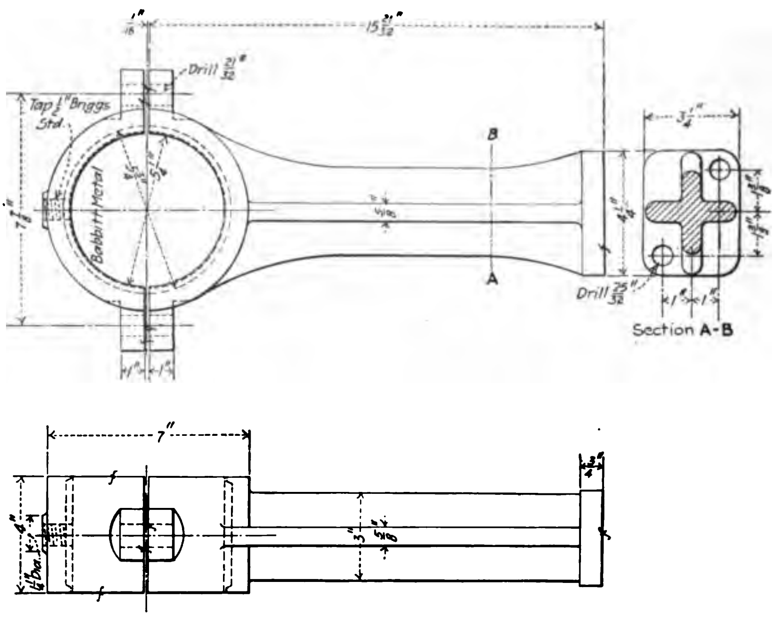


FIG. 108.—Drawing of Counter Shaft Box Shown in Fig. 107.

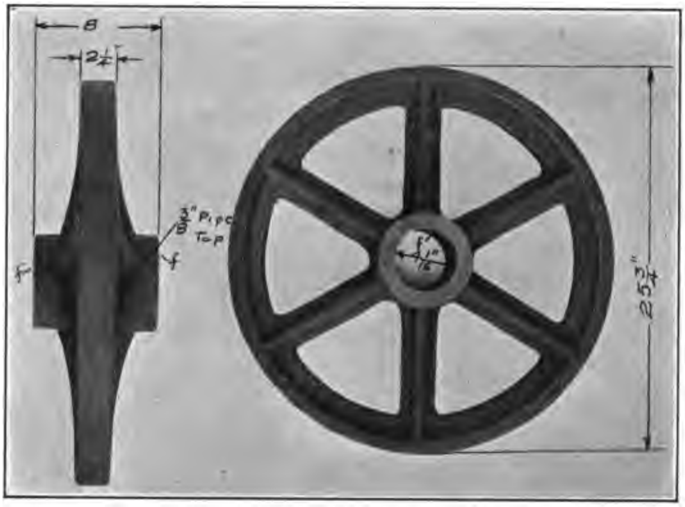


Fig. 109.—Flywheel.

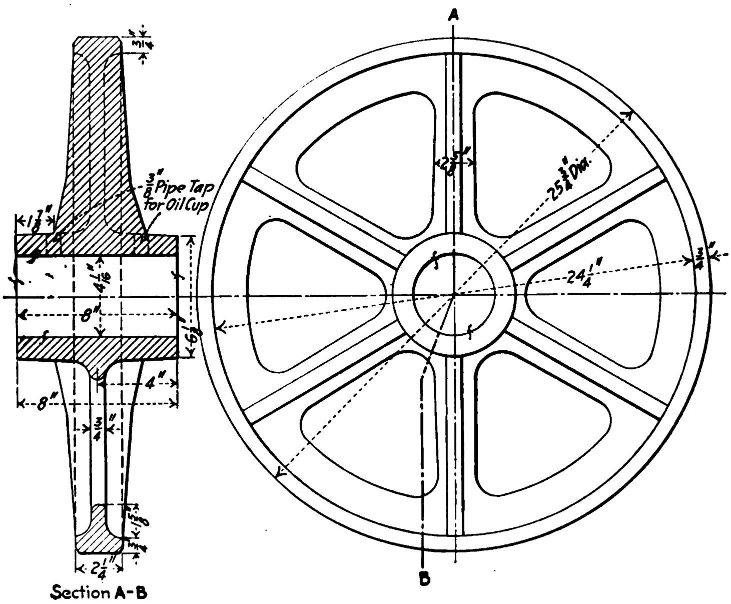


Fig. 110.—Drawing of Flywheel Shown in Fig. 109.

this drawing will constitute good practice in cross hatching as will also the making of the drawing of the friction disk, which is illustrated photographically by Fig. 111 and by line drawings in Fig. 112.

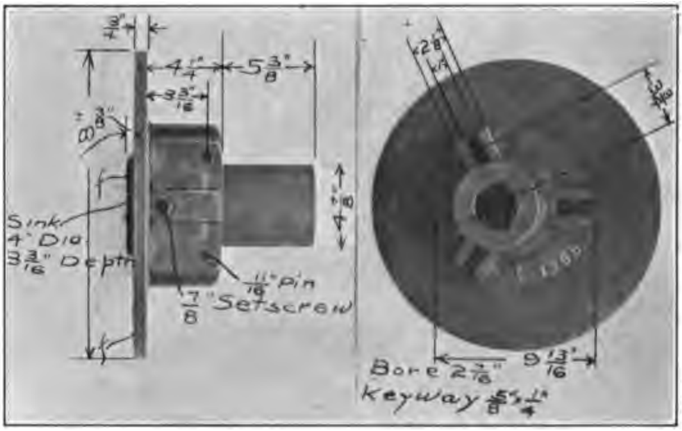


Fig. 111.—Friction Disk

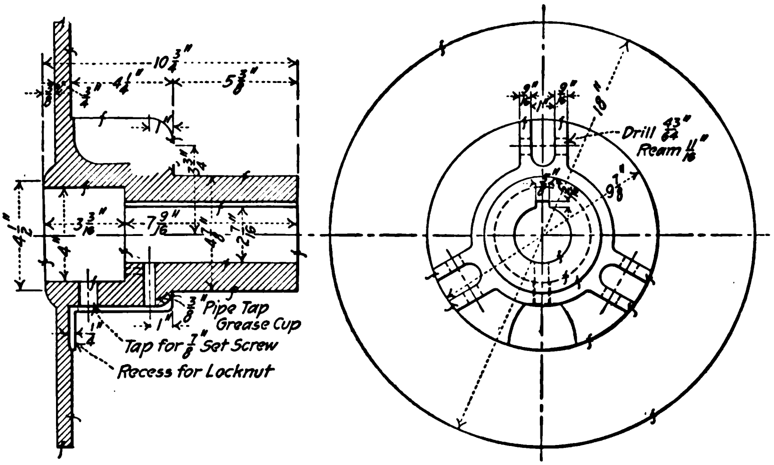


Fig. 112.—Drawing of Friction Member Shown in Fig. 111.

Still another interesting example of practical drawing work in projection and sectioning is presented in Fig. 113 and in the line drawing Fig. 114. The views in the drawing are not those in the photograph and the student will find it of value to draw an additional view showing the exterior of the pipe member from the side and place this elevation over the section at the left of Fig. 114. It will be seen that the plan view is of one half of the casting only. This is merely a device often resorted to in order to save space where a drawing is rather large to put in full on the paper. In drawing this piece it will be well to show the plan in full outline.

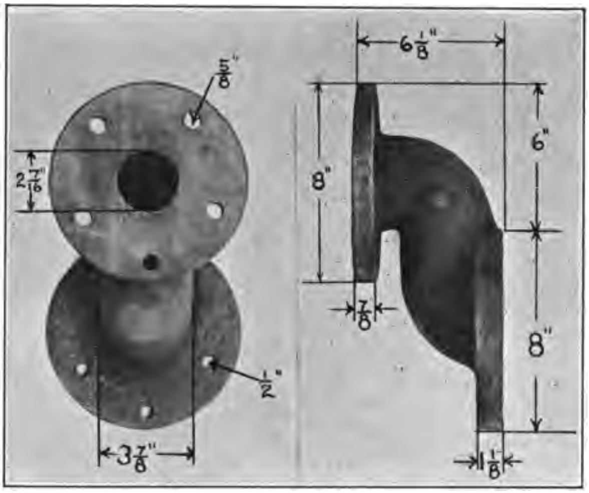


Fig. 113.—Pipe Bracket.

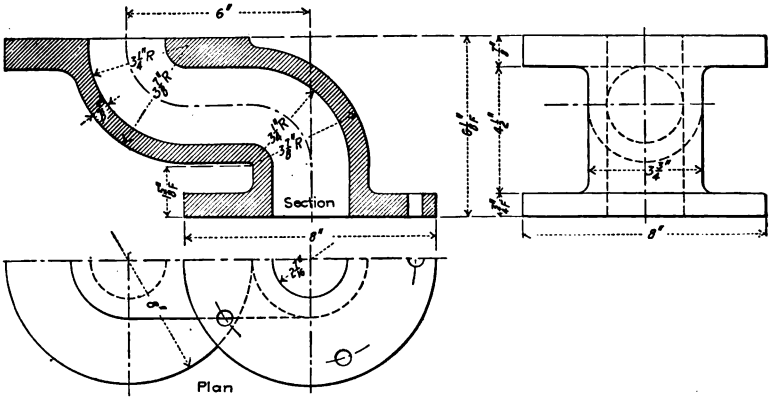


Fig. 114.—Drawing of Pipe Bracket Shown in Fig. 113.

ENGINE AND COMPRESSOR PARTS

In Fig. 115 a single photographic view is given of a packing ring part with cylindrical outside surface and conical interior.

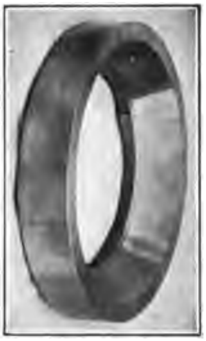


FIG. 115.—Packing Ring.

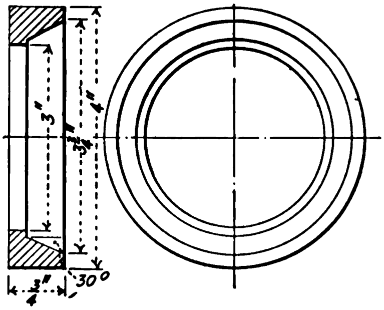


FIG. 116.—Drawing of Packing Ring Shown in Fig. 115.

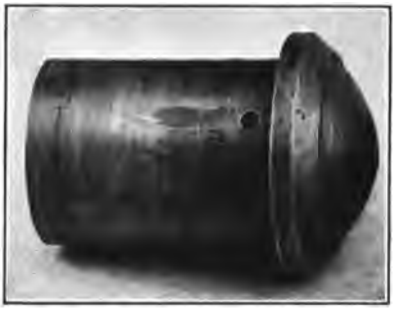


FIG. 117.—Air Compressor Valve.

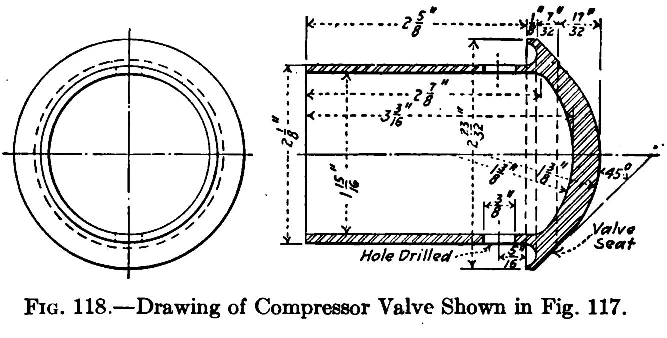


FIG. 118.—Drawing of Compressor Valve Shown in Fig. 117.

The most practical way to show this on a drawing is by two projections or views, namely a plan and a section in place of an outside side elevation. Thus Fig. 116 containing two simple views gives all the dimensions required for the making of such a part.

Fig. 117 is an air compressor valve which is fully shown for manufacture by the line drawing, Fig. 118. Here there is also a plan view and a longitudinal section.

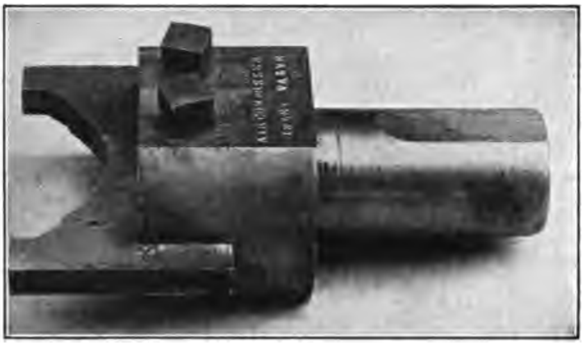


Fig. 119.—Brass Lathe Tool for Valve Head.

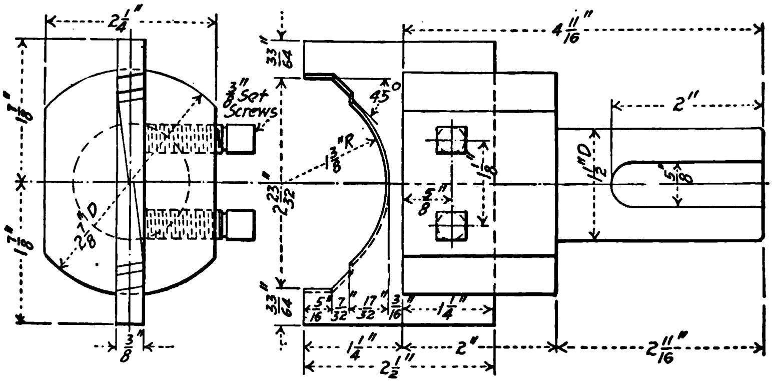


Fig. 120.—Drawing of Valve Tool Shown in Fig. 119.

Fig. 119 is a photograph of a tool used in the brass lathe for finishing the heads of such valves as represented by Figs. 117 and 118. Fig. 120 shows the working drawing of the tool in plan and elevation.

The connecting rod, Fig. 121, is for a high speed marine set.

The drawing of this is in three views, plan, front and end elevations, Fig. 122. Note the partial section *A* through the cap, the cross-section *B* of the large end of the rod proper and the cross-section *C* through the side fork.

Fig. 123 shows a special adjustable planer tool for use in finishing shoes and wedges for locomotives. The two tools in the head of the appliance may be set out to desired width of point by releasing the set screws and adjusting the cutters in their seats. The drawing for this tool, Fig. 124, has one view *M* in an auxiliary plane in order to show an end view perpendicular to the center line along the axis of one of the cutters. This shows the true shape of the cutting tool and the adjusting screw behind it.

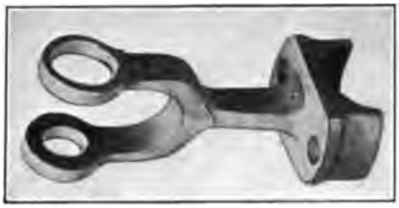


FIG. 121.—Connecting Rod.

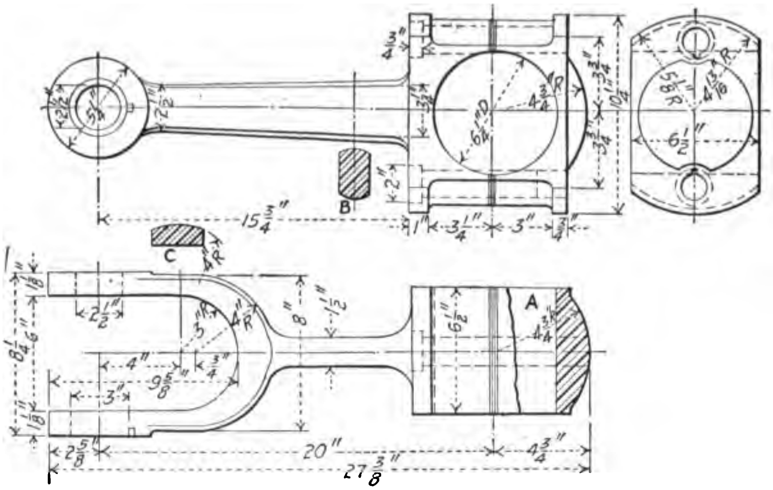


FIG. 122.—Drawing of Connecting Rod Shown in Fig. 121.

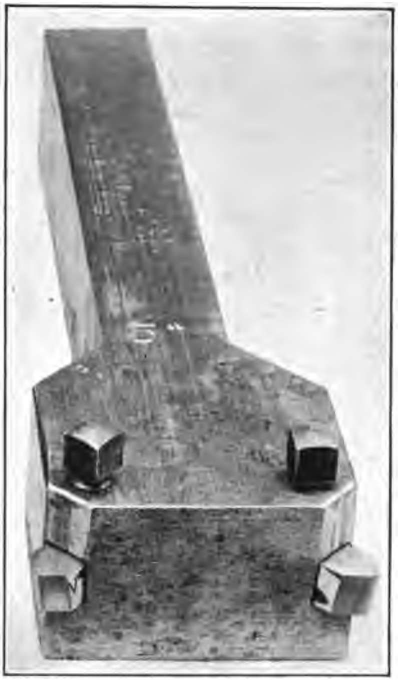


FIG. 123.—Adjustable Planer Tool.

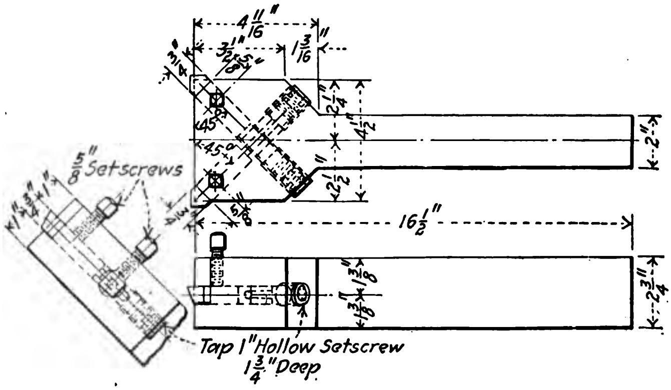


FIG. 124.—Drawing of Planer Tool Shown in Fig. 123.

MISCELLANEOUS EXAMPLES

For further practice in projection the reader will do well to lay out in plan and elevations the different machine parts

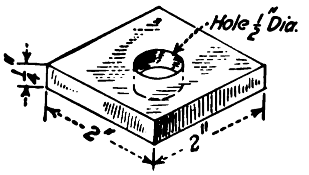


FIG. 125

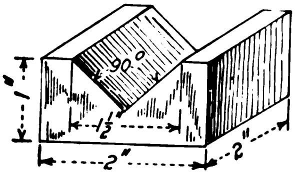


FIG. 126

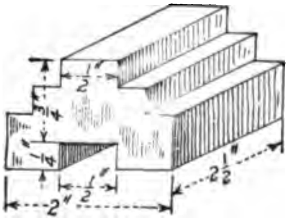


FIG. 127

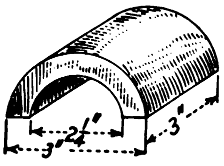


FIG. 128

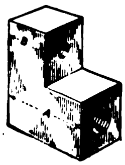


FIG. 129

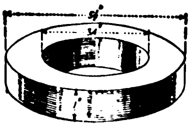


FIG. 130

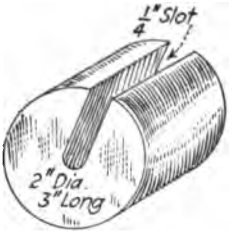


FIG. 131

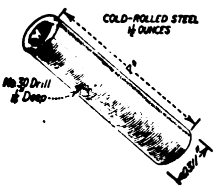


FIG. 132

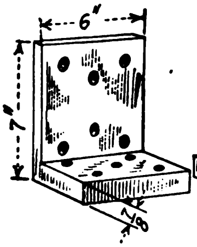


FIG. 133

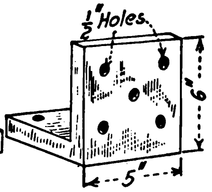


FIG. 134

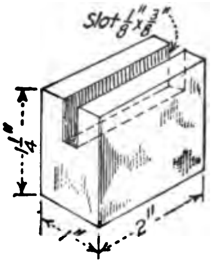


FIG. 135

and accessories shown in perspective in Figs. 125 to 153. With the exception of a few cases these are all capable of being shown clearly by two views, that is, a plan and one

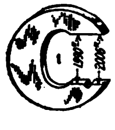


FIG. 136

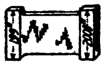


FIG. 137

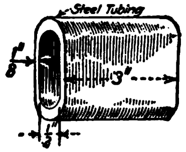


FIG. 138

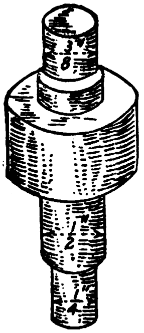


FIG. 141

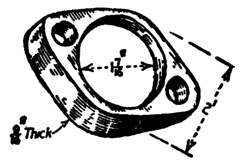


FIG. 139

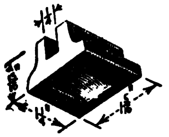


FIG. 140

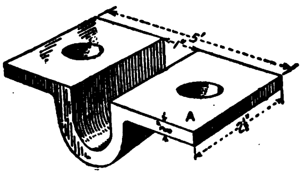


FIG. 142

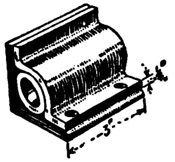


FIG. 143

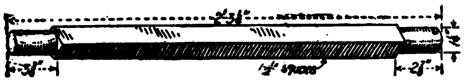


FIG. 144

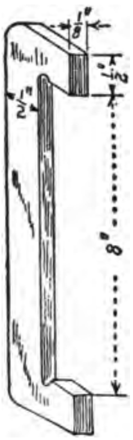


FIG. 147

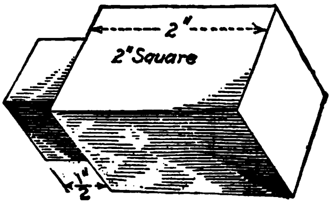


FIG. 146

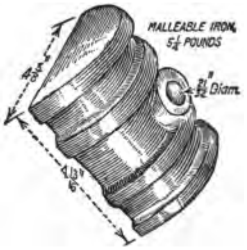


FIG. 145

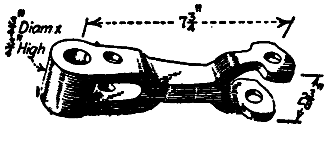


FIG. 148

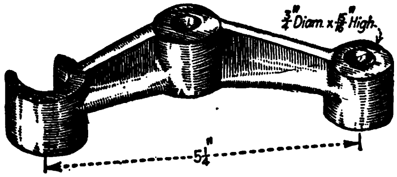


FIG. 149

elevation. Those which should be drawn in three views are Figs. 143, 148, 149, 150, 151, 152, 153. In some cases only a few dimensions are given and in a few instances all dimensions are purposely omitted. This will give the student ample opportunity to supply from observation or from experience such dimensions as may be required for completing the drawing. All of these drawings should be made in third-angle projection, as explained in the preceding chapter.

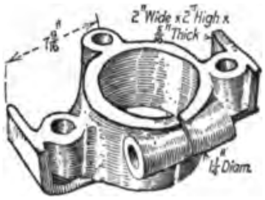


FIG. 150

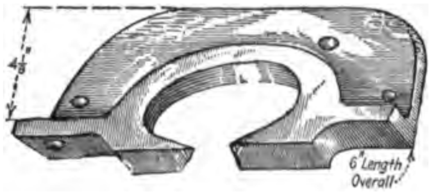


FIG. 151

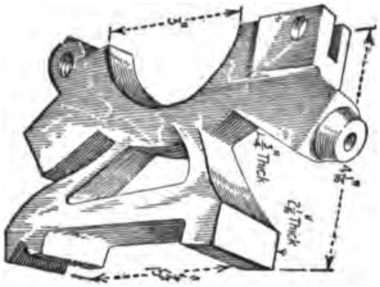


FIG. 152

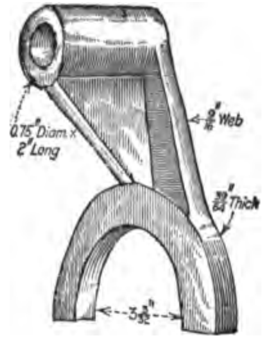


FIG. 153

OCCASIONS WHERE FIRST-ANGLE PROJECTION IS PREFERABLE

It has been stated in Chapter II that in certain cases first-angle projection is preferable to third-angle projection and even though the practice of the drawing room may be almost exclusively third-angle work, once in a while an exception is made for the sake of a certain degree of clearness on a special drawing. In such cases each view should be marked as to whether it is top or bottom plan, inside or outside view so that no misunderstanding may occur in the reading of the drawing.

Suppose we wish to make a drawing of a set of dies such for example as Fig. 154. Here is a tool job where there is a definite advantage in first-angle projection. In the first place it is a very desirable arrangement to show the punch and die together in the front elevation as in Fig. 155, this being especially so where the tools are of the sub-pressed or pillar type here illustrated. So with punch head placed over the die pillars, as in Fig. 155, we can by first-angle projection show the lower or working face of the punch directly over the front elevation of the punch and similarly show the plan of the die immediately under the elevation of the die. This is the logical arrangement of views for such parts.

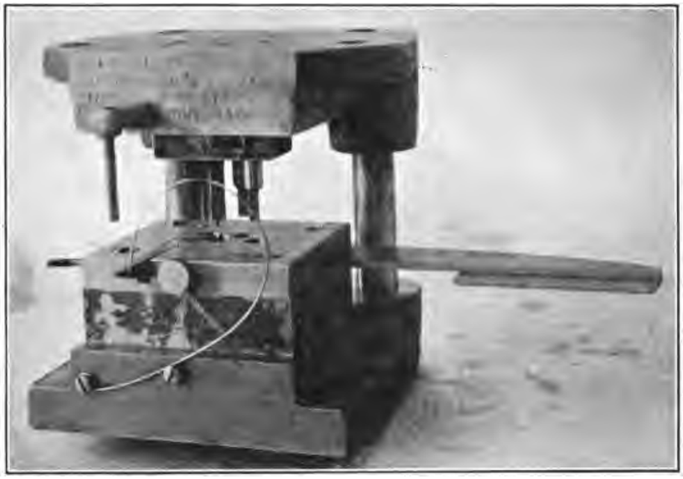


Fig. 154.—Punch and Die.

But with third-angle projection which is so desirable in ninety-nine cases out of a hundred, the placing of the views in the above arrangement brings them as in Fig. 156 with a *dotted* plan of the punch over the front elevation and a *dotted* plan of the die face under the elevation. This is entirely unsatisfactory particularly where there is considerable detail to work into the plan views.

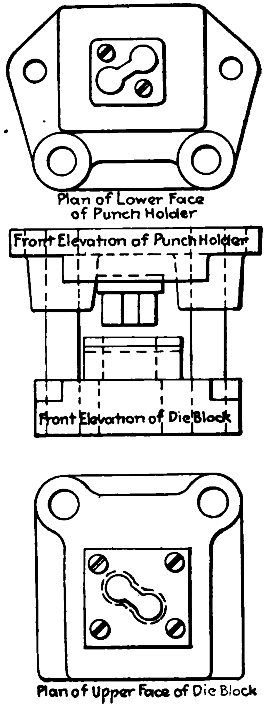

Plan of Lower Face of Punch Holder
Front Elevation of Punch Holder
Front Elevation of Die Block
Plan of Upper Face of Die Block

FIG. 155.—Punch and Die Shown in First Angle Projection.

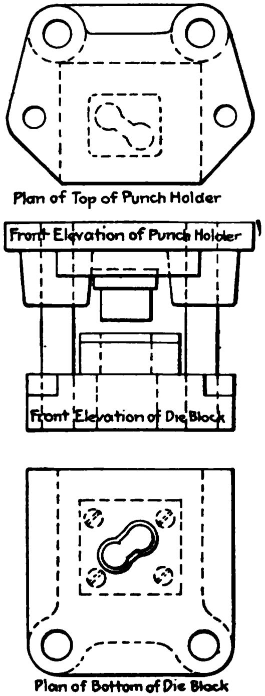

Plan of Top of Punch Holder
Front Elevation of Punch Holder
Front Elevation of Die Block
Plan of Bottom of Die Block

FIG. 156.—Punch and Die Shown in Third Angle Projection.

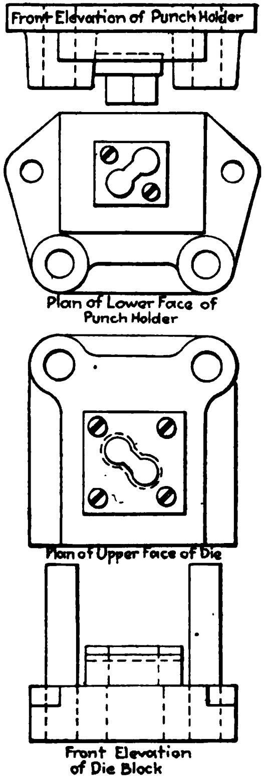

Front Elevation of Punch Holder
Plan of Lower Face of Punch Holder
Plan of Upper Face of Die
Front Elevation of Die Block

FIG. 157.—Punch and Die in Third Angle Projection, Showing Working Faces of Both Members.

An alternative third-angle arrangement is shown by Fig. 157 and this is frequently resorted to where no exceptions from third-angle are permitted in the drawing office. This arrangement of views has certain definite objections from the toolmakers point of view: The punch and die are separated in the elevation and the matter of clearances under stroke, the total height of assembled dies, and the alinement of various details are not so easily understood as where the two members are shown together in elevation as in Fig. 155.

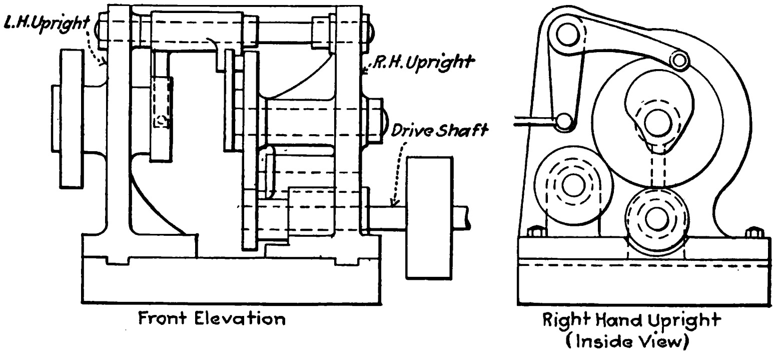


FIG. 158.—Showing Occasional Advantage of First Angle Projection.

There is another class of work where first-angle projection has its advantages. That is where assembled views carry most of the mechanism inside of end walls and the like as in Fig. 158. If this drawing were made in third-angle projection, the side housings would carry most of the mechanism in dotted lines only. But by swinging the side uprights around in first-angle all of the inside detail is clearly shown by the usual full lines. Thus the end view marked "Righthand Upright, Inside View," explains the situation and there should be no legitimate chance for error in reading such a drawing.

CHAPTER IV

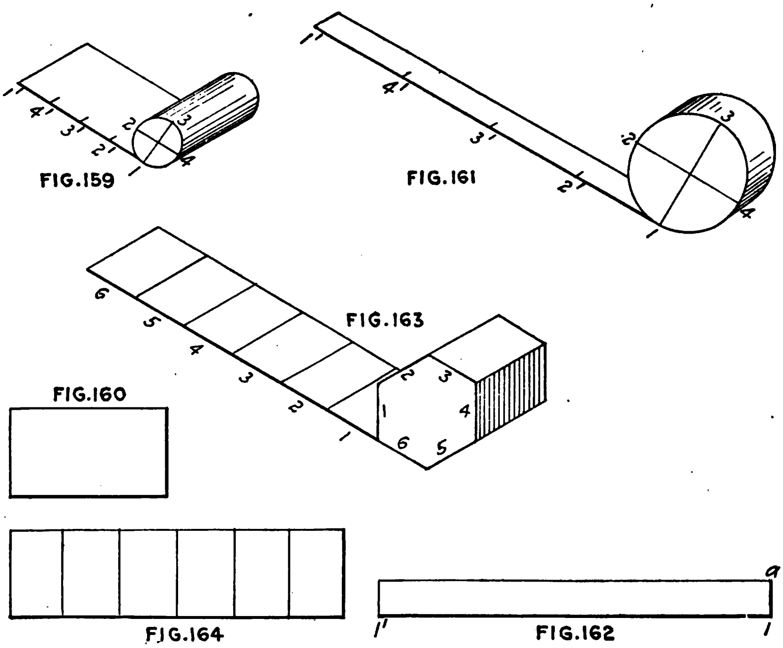
DEVELOPMENT OF SURFACES—INTERSECTIONS

The development of a surface is the layout in one plane of the entire surface of an object. Thus if we have a sheet metal tube, Fig. 159, and split that tube along line 1 we can open it out and form the flat sheet, Fig. 160. If we split the tube and roll it out along the board as in Fig. 159 the point 2 on the circumference will fall at point 2′, point 3 at point 3′, point 4 at 4′. The surface of a solid body may be similarly developed. That is, shown in one plane. Fig. 161 is a roller. The development of its surface is simply a layout of its circumferential area the length of the rectangle formed being the same as the circumference of the roll, the width the same as the width of the roll face. Thus the points 2′, 3′, 4′, 1′, in Fig. 161 are merely the positions of arbitrary points 2, 3, 4 and 1 on the roll if this were to be rolled along the paper and any point on its periphery transferred to the paper. So the development of the roll surface as actually laid out would be as in Fig. 162. If we know the diameter of such a roll and multiply it by 3.1416 we have the actual circumference and can thus establish at once the length of line 1-1′, Fig. 162. The width 1-*a* is of course the same as the width of the roll face.

The hexagonal object, Fig. 163, is similarly surface-developed as shown by that illustration and by Fig. 164. Each flat surface on the hexagonal form gives one-sixth of the total area of the developed surface. The small rectangles in Fig. 164 are not laid out in actual practice but are shown to indicate the six faces of the object as developed.

If we take a cone of sheet metal, Fig. 165, and split it open from base to point and then unroll it to bring it to a flat plane we produce the sector of a circle as shown. The radius of this sector is equal to the slant height of the cone. If the hexagonal pyramid, Fig. 166, is developed the flat area formed is composed of the six triangular sides making the fan like figure illustrated.

Sheet metal and boiler work require many interesting layouts of surfaces and these involve the use of projection for



Development of Surfaces.

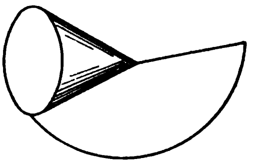


Fig. 165.—Cone.

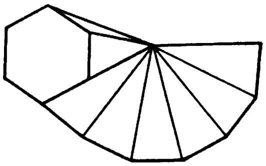


Fig. 166.—Pyramid.

we must first show different views of the object before the developed layout is made. In workshop practice the surfaces developed must usually have a certain allowance added for seams, overlaps, and various kinds of joints but it is unnecessary to take these into consideration at this point in our study of the development of surfaces proper.

DEVELOPMENT OF CYLINDER CUT AT AN ANGLE

Say we have a thin cylinder as a pipe section which is cut at an angle as in Fig. 167. We draw the plan and the elevation, and show the angle of cut across the top. Now if we divide the circumference in the plan view into a certain number of equal parts, say, 12 in this case, we obtain points 1, 2, 3, etc. Now when we project these points vertically onto the elevation we find the lines of projection intersecting the slanting edge at points 1′, 2′, 3′, etc. These represent the length or height of what we call the elements of the surface and from them we make our layout of the surface development.

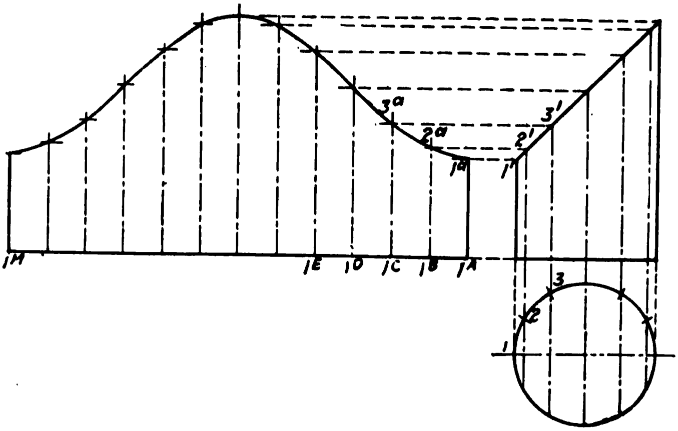


Fig. 167.—Development of Cylinder Cut at an Angle.

At the left of the elevation lay out line 1*A*-1*M* equal to the circumference of the cylinder. (Take any convenient diameter for drawing the cylinder and multiply by 3.1416 to get the circumference.) On this circumference or base line 1*A*-1*M*, lay off the same number of divisions 1*A*, 1*B*, 1*C*, 1*D*, etc., as on the plan view, or twelve in all. Now by projecting perpendicular lines from these points we establish the elements in the development of the surface, and by projecting horizontal lines from the corresponding elevation points 1′, 2′, 3′, etc., we cut lines 1*A*, 1*B*, etc., at the correct height. Thus the horizontal line from point 1′ intersects vertical line 1*A* at point 1*a* and horizontal line from point 2′ intersects vertical line at point 2*a* and so on. Thus we get the points through which to draw the curve which shows the true developed form of the angular end of the cylindrical pipe.

Another way to consider the development of such a surface is to bear in mind that the end of the cylinder cut at an angle forms an ellipse as in Fig. 168. If we lay out the development of the surface as before and draw the ellipse representing the slanting end of the cylinder we can roll this ellipse along the curved upper edge of the development and point *A* will start at *A′* on the development, point *B* will coincide with *B′* on the development, point *C* will come to the upper point *C′* and so down the other side of the curve until *A* reaches *A′* which is

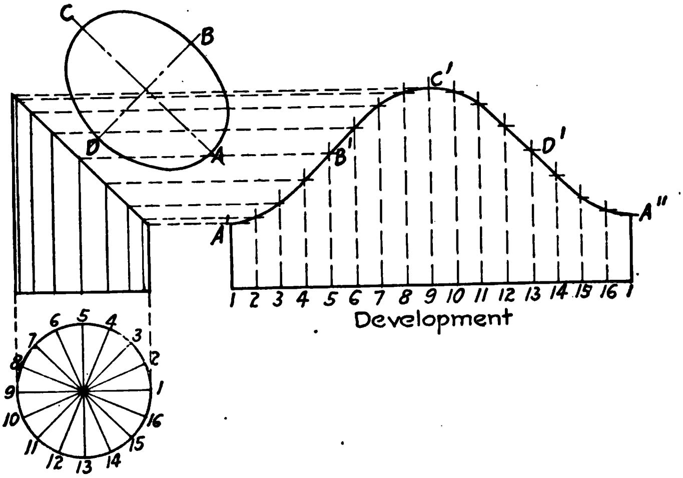
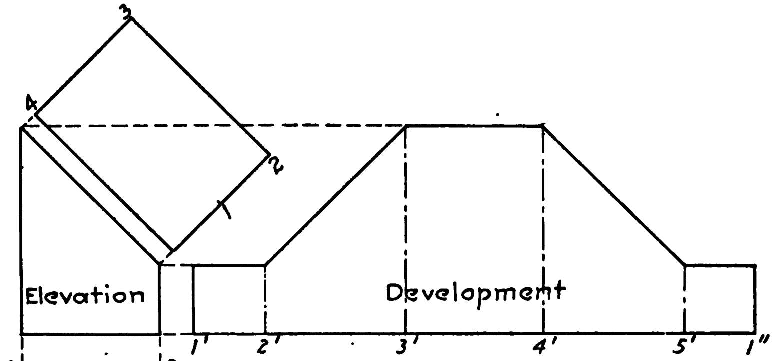


FIG. 168.—Development of Cylinder Cut at 45-Degree Angle.

the same as *A′*. In other words, the curved length of line *A′*, *C′*, *D′* is exactly the same as the distance around the ellipse *A*, *B*, *C*, *D*.

A SQUARE TUBE DEVELOPED

A similar problem is presented by Fig. 169. This is a square tube or flue with the upper end cut at an angle. We lay out the base line 1′-1″ four times the length of one of the sides and then consider that we cut the tube at the middle point 1 of one of the sides. Then lay off points 2′, 3′, 4′, 5′, 1″ making distance 1′-2′ equal to 1-2 of the plan and 5′-1′ the same distance. The other points are a distance apart equal to the length between corners 2-3, 3-4, 4-5, or one side of the flue. Now erect perpendiculars from 1′, 2′, 3′, 4′, 5′, 1′, and cut them with horizontal lines projected from the corresponding corners of the elevation. Join the points of intersection on the development and thus complete the outline of the developed surface.



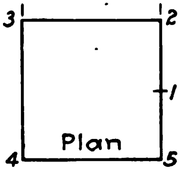


FIG. 169

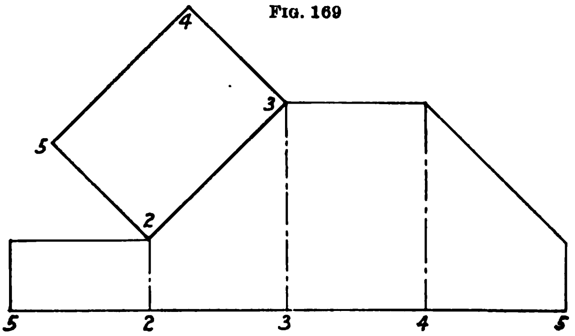


FIG. 170

Development of Surfaces

The auxiliary projection of the square tube when cut at the angle shown is a rectangle as represented. If, as in Fig. 170, we place the rectangle on the developed surface, the short side will coincide with 5-2 of the development, the long side of the rectangle will coincide with the slanting line of the development and so on with the remaining two sides.

HEXAGONAL FIGURES

Fig. 171 shows the development of a hexagonal body which has been cut at an angle. The plan of the slanting face shows the elongation of the hexagon due to the angle of cut. The base line for the development of the surface is divided into six parts and the perpendiculars thereon erected are intersected by horizontals from the elevation of the object to the left. The method of completing the figure will be seen without explanation.

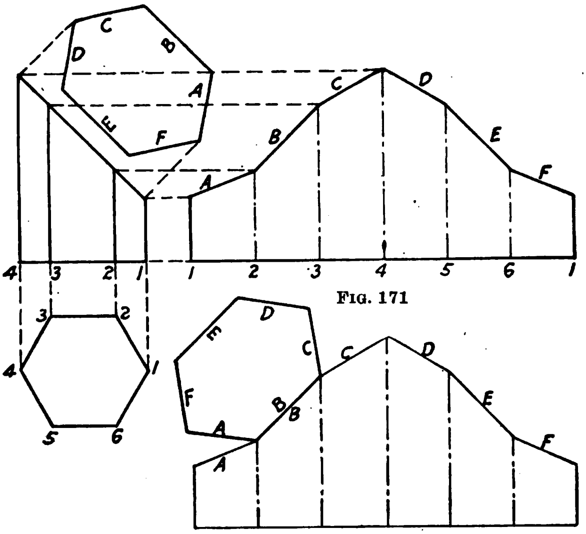


FIG. 171

FIG. 172

Development of Surfaces.

Fig. 172 should be examined for an understanding of how the elongated six sided figure forming the slanting face of the object matches side by side each angular section *A, B, C,* etc., of the developed surface.

The six sided pyramid in Fig. 173 has been cut off at an angle and the development of the surface is required. The lower line of the surface development is similar to that in Fig. 166 and merely represents the fan shaped formation of the six triangles below the point where severed by the cutting plane through the pyramid. The upper line 1*a*, 4*a*, 1*a*, is more difficult to lay out. Lines 1-1*a*, and 4-4*a* may be laid off directly from the same lines on the elevation to the left for these lines are there shown in their true lengths. But the intermediate lines from points 2 and 3 on the elevation are not shown in their true length. Therefore where line 1*A*, 4*A* cuts these lines in the elevation draw horizontal lines 2*B* and 3*B* and then transfer distance 1-2*B* and 1-3*B* to the development where line 1-2*B* becomes 2-2*B* and line 1-3*B* becomes 3-3*B*. Joining the various points now obtained on the radial lines of the development gives us the contour of the upper edge, or 1*a*-2*B*-3*B*-4*a*-3*B*-2*B*-1*a*.

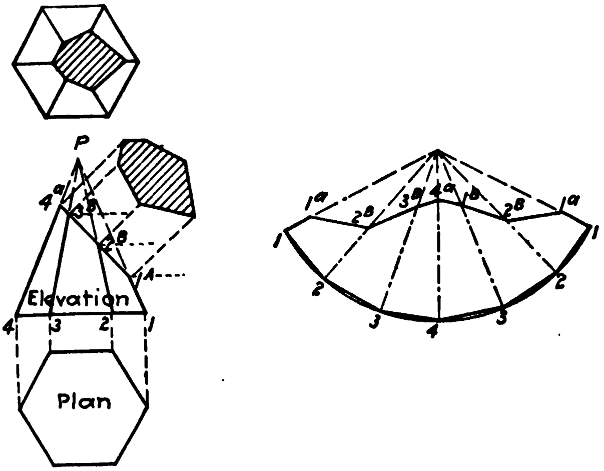


FIG. 173.—Development of Surfaces.

ELLIPTICAL FORMS

Let us consider for a moment the elliptical forms produced by cutting planes passed at an angle through a cylinder. Refer to Figs. 174 and 175. Taking first the former illustration, we have the cylinder shown in plan and elevation. Lay off points 1, 2, 3, 4, 5, or any other convenient number. These need not be equispaced about the circumference. Draw lines through these points horizontally across the circle, and project them along the elevation until they cut the slanting face at the right, these are the elements of the cylinder. Then draw center line *a-b* parallel to the sloping face and perpendicular to this draw lines from the elements as 1′-1′, 2′-2′, 3′-3′, 4-4′, 5-5′. Lay off on these lines each side of the center line *a-b*′, distance *C*′-1′ equal to *C*-1 of the plan, distance *C*′-2′ equal to *C*-2 and so on, thus establishing points 1′, 2′, etc., through which the curved outline is drawn forming the ellipse.

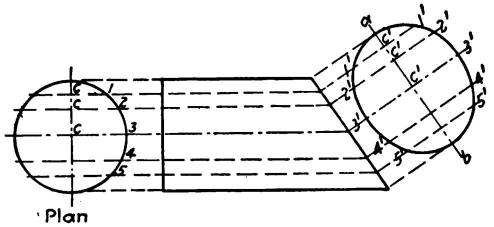


Fig. 174.—End of Cylinder Cut at an Angle.

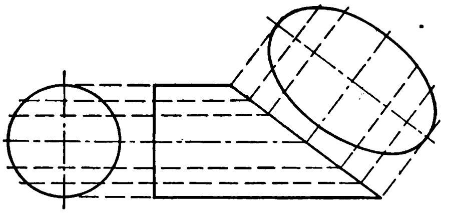


Fig. 175.—End of a Cylinder Cut at an Angle.

The longer ellipse of Fig. 175 is drawn in the same manner. It will be noted that this is formed by cutting the cylinder at a sharper angle than in the case of Fig. 174. The student should practice on layouts of this kind as this is the form in which piping is cut to form bends, angles and the like. Fig. 176 shows a pipe joined at 45 degrees with a similar pipe to form a right angle bend and Fig. 177 is a three section bend forming a right angle. The middle section here has an included

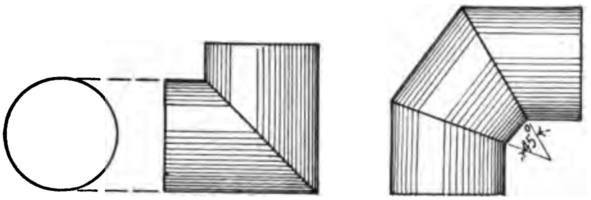


Fig. 176 Fig. 177

Intersection of Cylinders.

angle of 45 degrees so that the angle at the ends of the outer sections is 22½ degrees. Lay these out for a six inch pipe and develop the surfaces of the sheet metal for each section. Refer back to Figs. 167 and 168 for developments of this kind.

INTERSECTIONS AT RIGHT ANGLES

A common intersection in sheet metal work is that represented in Fig. 178 where one member is joined to another larger member at right angles. The drawing of the end view is simple but the side view requires the finding of a series of intersection points *c′*, *a′*, *b′*, *d′*, for establishing the curved line joining the small cylindrical dome at the top to the horizontal cylinder.

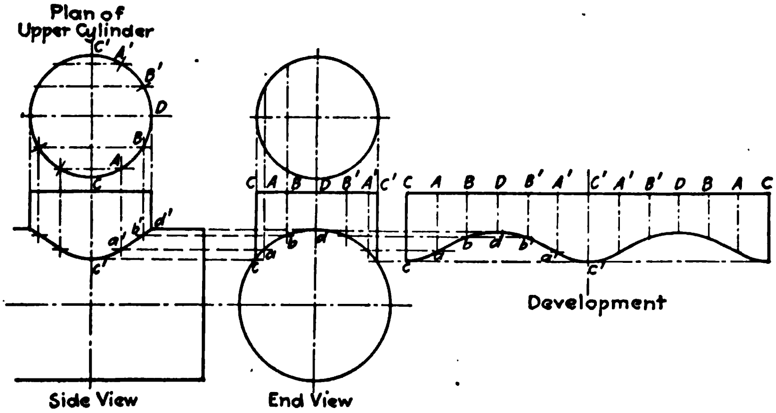


FIG. 178 FIG. 179
Intersection of Cylinders.

Find these points in the curve as follows: Space off a series of divisions on the plan of the upper cylinder thus, *C, A, B, D, B′, A′, C′*, and draw horizontal lines *A, B, D*, etc. Where these lines intersect the circle drop perpendicular lines onto the lower cylinder. In the end view of the cylinders draw the same lines *C, A, B, D*, etc., across the circle of the upper cylinder, only in this view these lines will run vertically instead of horizontally. Extend these lines downward onto the lower cylinder which they intersect at points, *c, a, b, d*, etc. If we consider the upper cylinder to be split along lines *A, B, D*, the segments which could be removed one by one would intersect the lower cylinder at these points, *a, b, d*. These lines we call the elements of the upper cylinder and their projection in the side view has already been referred to. Now if we run horizontal lines from points *c, a, b, d,* in the end view to vertical lines *c′, a′, b′, d′,* in the side view, the points of intersection, *c′, a′, b′, d′*, are the required points through which to draw the curve joining the two cylinders. This curve is of course the same at both sides of the center line *C′-c′*.

The development of the sheet for forming the upper cylinder is shown in Fig. 179. The length of the sheet is divided into the same number of parts as the circle of the cylinder and the vertical lines dropped from these divisions are made to correspond in length to the series of lines *C, A, B,* etc., in the elevations.

CYLINDERS AT AN ANGLE

Fig. 180 shows a cylinder joining at an angle another larger cylinder. The difference between this and the former problem in Fig. 178 is due to the angular position of the upper cylinder in Fig. 180. This gives a different shape of curve of intersection at each side of the oblique center line, *O-O′*.

If we draw on the true end view of the upper cylinder (which is a circle) a series of splitting lines 1, 2, 3, we can project from their points of contact with the circle a series of angular lines parallel to *O-O′* which extend down to the lower cylinder as 1′, 1*a*, 2′, 2*a*, 3′, 3*a*. These are elements and in the end view of the cylinders to the left they show as perpendicular lines which intersect the circle of the lower cylinder at *A, B, C, D.* Horizontal lines drawn from these points to the right intersect the angular lines in the side view at points 3′, 2′, 1′, *O′*, 1*a*, 2*a*, 3*a*, and these form the points through which to draw the curve showing the line of intersection of the two cylinders.

A simple way to arrive at an understanding of the intersection of two such cylinders is to consider the lower or horizontal cylinder as a milling cutter as in Fig. 181. This is supposed to be the same diameter as the cylinder which it represents. Now if we bring it in contact with the upper cylinder (which is inclined at the same angle as in Fig. 180) we can mill out the bottom edge to the exact form which it would require to fit exactly to the lower cylinder. Consider each tooth of the milling cutter which is in contact with the work to represent a cutting plane on the upper cylinder. By drawing horizontal lines from the points of the teeth in the end view across the side view we locate the teeth in the latter view and where they intersect the angular lines dropped from the tooth positions *O*, 1, 2, 3, we obtain points *O′*, 1′, 2′, 3′, etc., for the curved path of intersection of the upper cylinder with the lower.

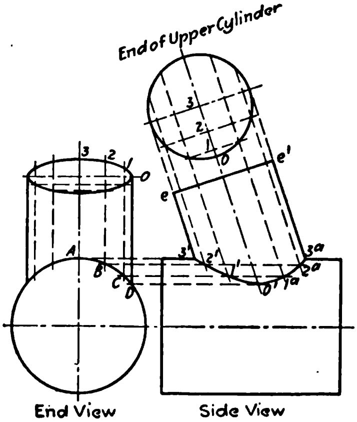


FIG. 180

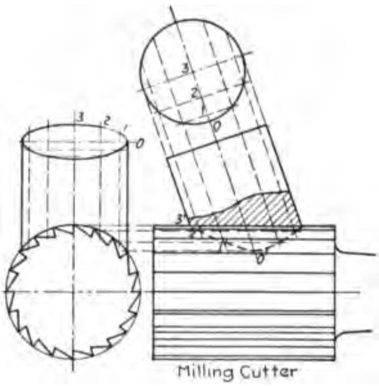


FIG. 181

Intersections of Cylinders.

SECTIONS OF THE CONE

We have already found that by cutting the cylinder at an angle we produce an elliptical form. In Fig. 182 we have one of the conic sections, an ellipse, formed by a cutting plane passed through a cone at an angle to the axis or vertical center line. The cutting plane is represented by the line *a-b*. This cuts the walls of the cone at the points *A* and *G*. If now we imagine the portion of the cone between points *A* and *G* to be divided into a number of parts or disks by horizontal planes passed through at right angles to the axis we have say (in the elevation) lines *A-A, B-B, C-C, D-D, E-E, F-F, G-G,* one of which (*D-D*) passes through the center of cutting plane *a-b*. The other lines as *B-B, C-C,* etc., are not necessarily spaced to give equal distances between them. These lines representing the horizontal planes through the cone intersect the cutting plane *a-b* at points *A*, 1, 2, 3, 4, 5, *G*. In plan the horizontal planes or, we may say, the edges of the disks are circles and in the plan view of the cone the circles are designated by the same letters as in the elevation, namely *A′*, *B′*, *C′*, etc. Now if we drop perpendicular projection lines from intersection points *A*, 1, 2, 3, 4, 5, *G*, in the elevation to the circles *A′*, *B′*, *C′*, *D′*, *E′*, *F′*, *G′*, in the plan the line from point *A* will touch circle *A′* at the point of tangency; line 1 will intersect circle *B′* at 1′1′; line 2 will intersect circle *C* at 2′2′; line 3 (from the center of the cutting plane *a-b*) will intersect circle *D′* at point 3′3′; and

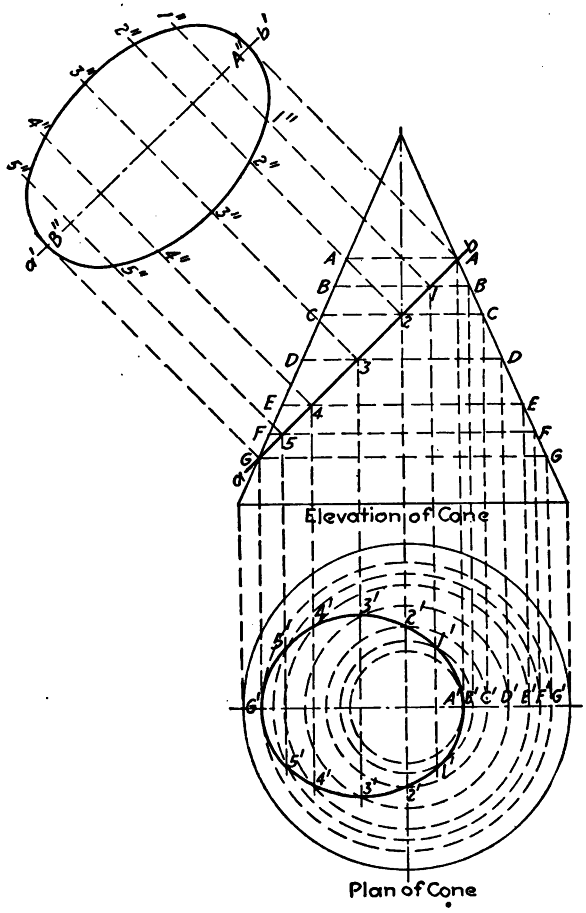


FIG. 182—Ellipse.

so on. The section of the cone is then represented in plan by the curved outline through points *A*′, 1′, 2′, 3′, 4′, 5′, *G*′.

The ellipse formed by the cutting plane *a-b* is shown in the auxiliary plane to the upper left where the major axis *a*′-*b*′ is parallel to the cutting plane *a-b*. Lines are projected across this axis perpendicular to line *a-b* and extending from points *A*, 1, 2, 3, 4, 5, *G*. On these lines points 1″, 1″, are laid off at the same distance apart as points 1′, 1′, in the plan view; 2″, 2″, are made equal to 2′, 2′; 3″, 3″, are laid off to the same distance as 3′, 3′, and so on. The ellipse is then drawn through points *A*″, 1″, 2″, 3″, 4″, 5″, *B*″, 5″, 4″, 3″, 2″, 1″.

THE PARABOLA

In Fig. 183 a cone is shown with a cutting plane *a-b* passed through its body parallel to the outside surface or slant height. The conic section thus produced forms a parabola. As before, a number of horizontal planes are supposed to be passed through the cone at points *A, B, C, D, E, F,* which cut the cone parallel to the base thus forming a series of disks. The diameters of the cone at the points cut are transferred to the plan view giving the circles *A*′, *B*′, *C*′, etc. Perpendicular lines dropped from points of intersection *A*, 1, 2, 3, etc., cut the circles in plan at points *A*′, 1′, 2′, 3′, 4′, 5′, *G*′. The auxiliary view at the left is laid out around line *a*′-*b*′, which is parallel to the cutting plane line *a-b* in the elevation. Perpendiculars from the points on this line are drawn through line *a*′-*b*′, and on the respective lines points 1″-1″ are laid off the same distance apart as 1′-1′ in the plan view; 2″-2″ the same as 2′-2′ and so on. The points for the parabolic curve are thus *G*″, 5″, 4″, 3″, 2″, 1″, *A*″, 1″, 2″, 3″, 4″, 5″, G″.

THE HYPERBOLA

The cutting plane in Fig. 184 passes through the cone at greater angle than the side of the cone, hence forms a hyperbola. In this instance the intersecting plane *a-b* is parallel to the axis of the cone. Two views would be sufficient for making the layout of the curve thus produced but the third view at the upper left hand will be of service in showing the path of the intersecting plane in its vertical projection. The horizontal lines *O*, 1, 2, 3, 4, 5, represent cutting planes parallel to the base of the cone, and the diameters of the cone surface cut by these planes are at *A-A, B-B, C-C,* etc. In plan these lines appear as circles *A′*, *B′*, *C′*, etc. The plane of intersection, *a-b* as seen in the plan view cuts these circles at points *O,* 1, 2, 3, 4, 5, 6. Running perpendiculars from these points to intersect the corresponding horizontal projections of these lines *A-A, B-B, C-C, D-D, E-E, F-F, G-G* in the front elevation we find the points of intersection as *O′*, 1′, 2′, 3′, 4′, 5′, 6′, and through these points we draw the curve known as the hyperbola.

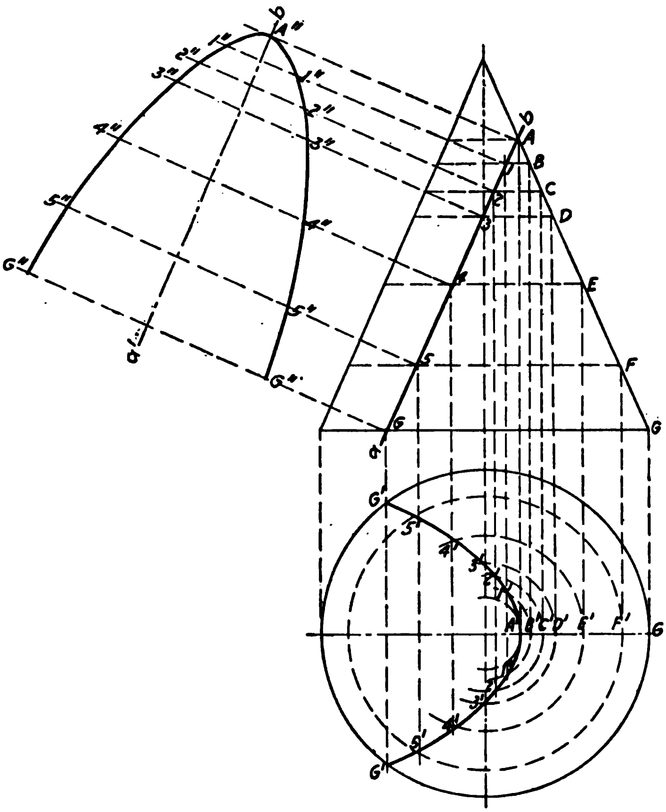


Fig. 183.—Parabola.

INTERSECTIONS ON MACHINE PARTS

Common examples of intersections coming up in machine drawing are such as shown in Figs. 185 and 186 where a hub or a boss meets the body of the piece at right angles or other angle. The machine handle in Fig. 187 is another case of this kind. The intersection of the handle with the body is here similar in character to the problem in Fig. 178 where one cylinder joins another of larger diameter at right angles. Compare the two cases and then draw the handle and show the line of intersection in Fig. 187.

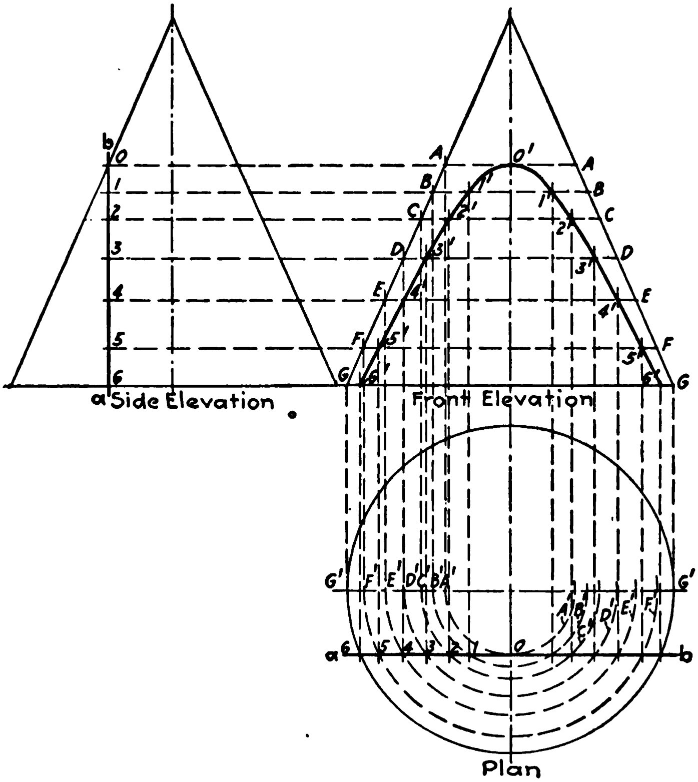


FIG. 184.—Hyperbola.

In Fig. 188 a flatted rod end is shown. The head of this rod is spherical with a large fillet running into the rod body and the two sides of the spherical end are flatted as shown.

Taking the curved contour, lay off equal divisions, as 1 to 7, and draw vertical lines cutting the curve at the points indicated. From these points draw horizontal lines intersecting the center line *A-B* of the end view at points 1′, 2′, 3′, 4′, 5′ 6′, and then draw circular arcs through these points to the flatted side of the rod. These arcs strike the flat surface at points *a, b, c, d, e, f.* From the latter points draw horizontal lines at the side

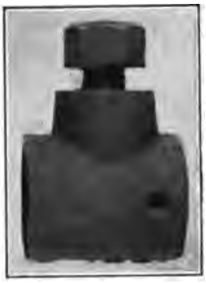


FIG. 185.—Showing Intersection of Round Boss on Collar.

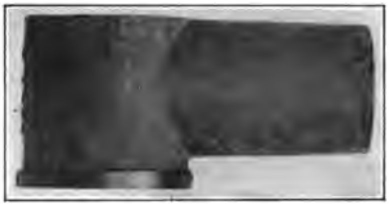


FIG. 186.—Showing Intersection of Round Lug on Sleeve.

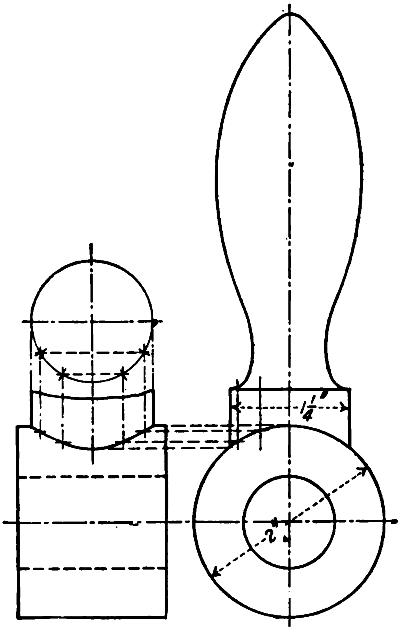


FIG. 187.—Intersection of Machine Handle with Hub.

view, and line *a* will cut vertical line 1 at point *a'*; line *b* will cut line 2 at point *b'*; line *c* will cut line 3 at point *c'*; and so through the series. Then draw a curved line through all of these points of intersection *a'*, *b'*, *c'*, *d'*, *e'*, *f'*, *g'*, and this will give the shape of the face as formed by flatting the ball end of the rod.

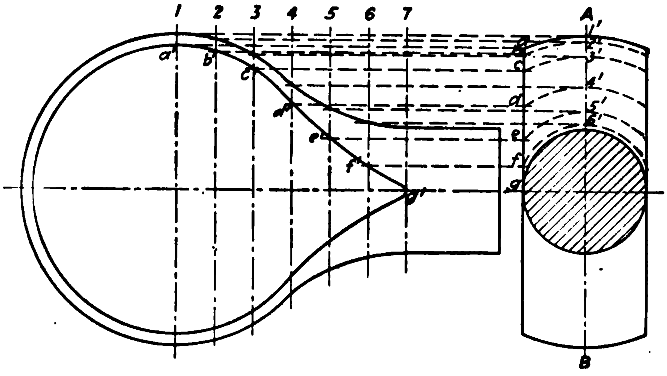


Fig. 188.—Flat End of Rod.

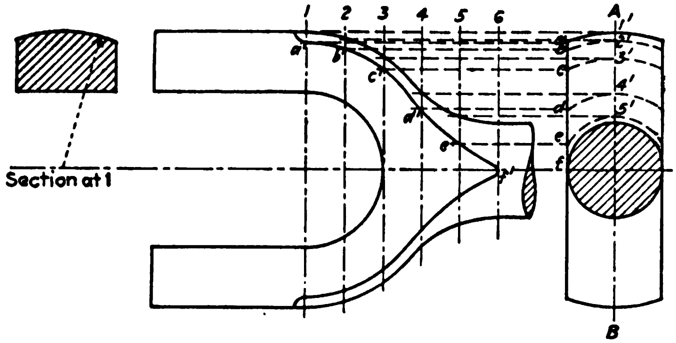


Fig. 189.—Connecting Rod.

In Fig. 189 a similar problem is involved where a connecting rod end is shown. Lay out such a rod to any convenient scale, and lay off a number of vertical divisions for the curved portion of the head and neck of the rod and project the necessary intersecting points onto the end view. Then draw the circular arcs and where these are ended by the flat face of the rod project horizontals back to the side view where the points of intersection are formed with the vertical divisions 1, 2, 3, etc. Through the intersecting points draw the curve *a'*, *b'*, *c'*, *d'*, *e'*, *f'*.

CHAPTER V

THE HELIX AND ITS APPLICATIONS

The most common application of the helix is found in the screw thread. Other examples are worm threads, spiral gear teeth, the teeth of spiral milling cutters, certain forms of cams, coiled springs, etc.

With a single helix like a single thread screw, as in Fig. 190, the longitudinal distance from one coil of the helix to the same point on the next coil or turn is commonly called the pitch. Thus distance *a-m*, Fig. 190, is known as the pitch. With multiple threads, as double, triple, quadruple, etc., the pitch is the longitudinal distance from one thread to the next, while the distance from one thread to the corresponding point on the *next turn of the same thread is really the lead.* That is with a double thread screw of say one inch pitch, this would mean that each thread in making one turn around the screw would advance two inches and the screw would have a 2 inch lead. But the distance from No. 1 thread to No. 2 thread would be 1 inch and this would be the pitch of the screw.

Referring to Fig. 190, the distance *a* to *m* is the pitch. If we divide this distance into a certain number of equal parts as 1*a*, 2*a*, 3*a*, and so on, and divide the circumference into the same number of parts which are here marked 1, 2, 3, 4, etc., we can draw horizontal lines from the latter to intercept the corresponding vertical lines dropped from points 1*a*, 2*a*, 3*a*, 4*a*, etc., and thus secure points *a, b, c, d, e, f, g, h, i, j, k, l, m,* through which the helical curve is drawn. From *g* to *m* the helix is on the hidden side of the body and is therefore dotted in. But the two halves of the curve are identical except of course one is the reverse of the other.

It will be seen from Fig. 190 that in advancing a certain part of the distance *a-m* parallel to the axis of the cylinder the helix also makes the same part of a revolution around the cylinder. That is, in advancing say one-twelfth the distance *a* to *m* or 1*a* to 2*a*, it also travels around the cylinder one-twelfth of a turn. Or in traveling one-quarter the distance from *a* to *m* it at the same time travels one-quarter around the circumference of the cylinder.

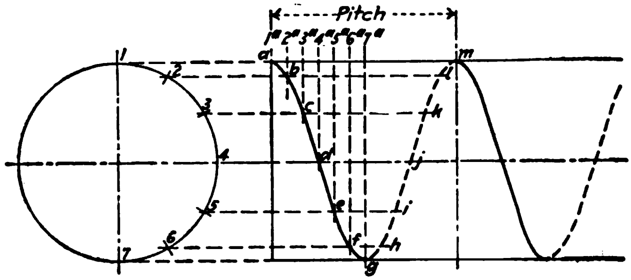


FIG. 190

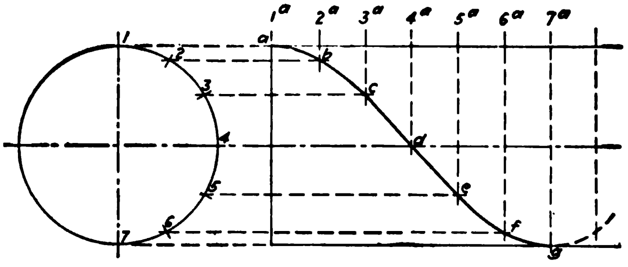


FIG. 191

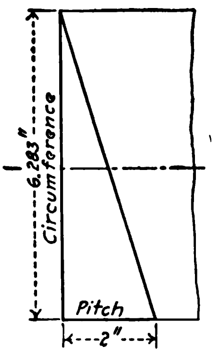


FIG. 192

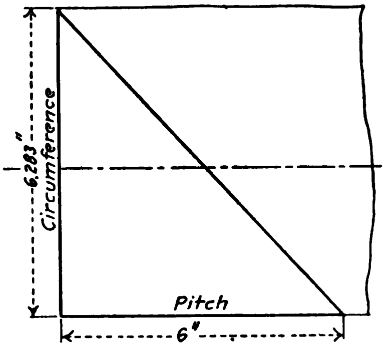


FIG. 193

The Helix.

The angle of the helix in relation to the axis of its cylinder varies in accordance with the diameter of the cylinder and the pitch. Thus in Fig. 192 is a layout to smaller scale of the development of the helix in Fig. 190. If we assume the diameter of the cylinder on which the helix is traced to be 2 inches, the circumference will be 6.283 inches. The pitch in this case is taken as 2 inches. The helix in Fig. 191 is traced around a cylinder of 2 inches diameter as in the previous case, but the pitch is three times as great or 6 inches. The development Fig. 193 shows the circumference to be the same as in Fig. 192 but the pitch is, as stated, 6 inches, so that the angle formed by the line of helix in respect to the axis or center line of the cylinder is entirely different from the angle of the other helix. Compare the two helical layouts or developments and note the effect of change in either the diameter of the cylinder or in the pitch of the helix itself.

A COILED SPRING

A coarse pitch coiled spring is shown in Fig. 194 as it would appear if drawn on the board to represent the actual curve of the helix. The layout is made on a diameter of circle equal to the center of the wire, that is, it is the outside diameter of the spring less the diameter of the wire itself. Thus in Fig. 194 a single helical line is laid out which represents the center of the coiled spring. This helix is drawn in the same way as the one in Fig. 190. Then the compasses are set to

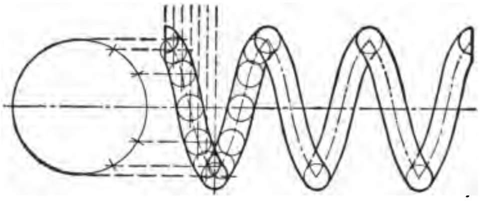


FIG. 194.—Open Coiled Spring.

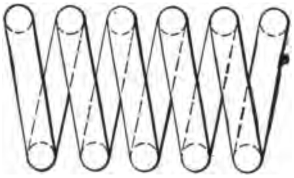


FIG. 195.—Common Method of Showing Spring.

draw a circle equal to the wire diameter and a series of circles are drawn along the helical center line as shown in Fig. 194. One of these circles will naturally be drawn at the top and bottom of each coil in the helix and at enough intermediate points to enable the helical curves representing the outside of the wire to be drawn in properly.

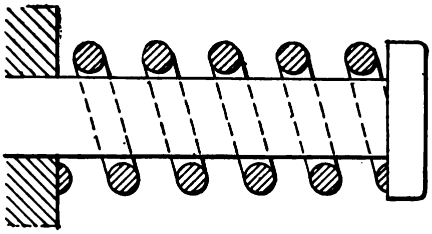


FIG. 196

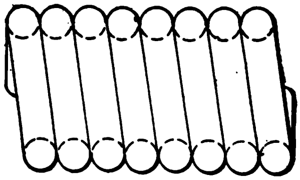


FIG. 197

Common Method of Showing Springs.

Generally speaking the draftsman does not bother to show such springs by helical lines. The usual practice is to draw the coiled spring in the manner shown by Fig. 195. That is by circles and straight lines connecting them. When the spring is to be shown enclosing some other part as in Fig. 196 it is often sectioned along the axis and the circles representing the wire diameter are cross hatched.

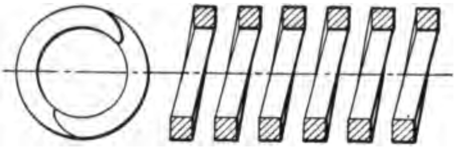


FIG. 198

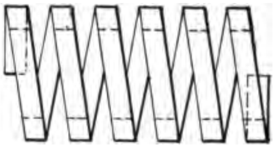


FIG. 199

Springs Made of Square Stock.

A close coiled spring is generally shown as in Fig. 197. Or if it is shown over a stud, rod, or other part it is usually split and cross hatched as in the case of the open spring, Fig. 196.

Springs are frequently wound from square or rectangular stock. The practice in showing such springs on the drawing is to make the views as in Fig. 198 and 199.

THE SCREW THREAD

The most common application of the helix is in connection with screw threads. In drawing such threads, however, it is generally the custom to indicate the helix by straight sloping lines, for the reason that most screw threads are of small ordinary sizes where simple conventional showing is all that is required. This feature is dealt with at length in the following chapter. For special cases, threads of unusual size, coarse pitch, etc., it is often desirable to lay out the curve of the helix and there are various problems arising in the tool room where it is important to be able to lay out the screw thread helix accurately in order to study the effect of threading tools, thread cutters and the like.

In Fig. 200 a screw thread of exaggerated pitch is shown to bring out clearly the helix at top and bottom of thread. In the end view the large circle 1 represents the outside diameter or top of thread, the small circle 1*b* represents the bottom or root diameter of the thread. The front view is laid off by drawing the profile of the threads or the *V* form of 60 degree angle, the pitch representing the distance from the top of one thread to the next. Divide the pitch into a number of uniform parts and drop perpendiculars as 1, 2, 3, 4, 5, 6, 7, and so on. Divide circle 1 and 1*b* into the same number of parts as 1, 2, 3, and 1*b*, 2*b*, 3*b*, 4*b*, etc. To get the points for the helix of the top of the thread, draw horizontal lines from the circle divisions 1, 2, 3, 4, 5, 6, 7, to the perpendicular lines 1, 2, 3, etc., and where horizontal 1 cuts vertical 1 find point *a;* where horizontal 2 cuts vertical 2 find point *b;* where horizontal 3 cuts vertical 3 find point *c.* This procedure gives us the points through which the helix may be drawn with the irregular curve for the top of the thread. Comparison of this with the simple helical line in Fig. 190 will show how the process is exactly the same as in that case and will also indicate the similarity of method in getting the points *h, i, j, k, l, m,* which give the curve for the portion of the helix at the back of the screw where it is indicated by the dotted lines.

For the root of the thread the above process is duplicated. Only here we project horizontal lines from the smaller circle in the end view these lines from points 1*b*, 2*b*, 3*b*, 4*b*, 5*b*, 6*b*, 7*b*, cutting vertical lines 1*a*, 2*a*, 3*a*, 4*a*, 5*a*, 6*a*, 7*a*, at points *a*′, *b*′, *c*′, *d*′, *e*′, *f*′, *g*′. The curve drawn through these latter points is

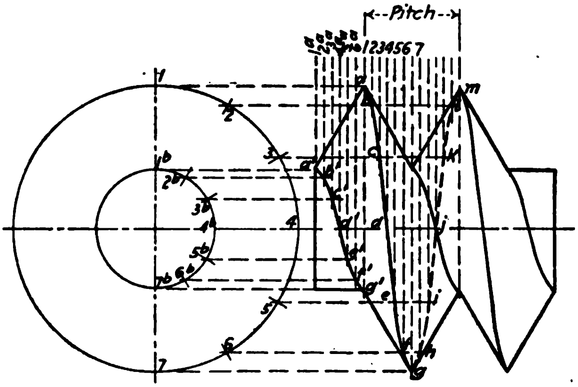


FIG. 200

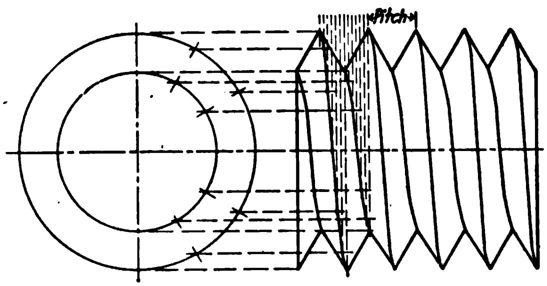


FIG. 201

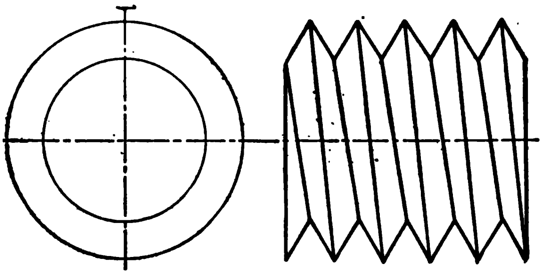


FIG. 202

Screw Threads.

the helix forming the root of the thread. That half of the root helix passing back of the thread is not here indicated by dotted lines, but it will be good practice for the student to locate the points in the curve and draw it in as in the case of the helix for the top of the thread.

In Fig. 201 a screw thread of common pitch is illustrated and it will be seen that the degree of curvature in both top and root helixes is much less pronounced than with the coarse pitch screw in Fig. 200. Draw such a screw thread and after laying out the *V* angles to 60 degrees along top and bottom in the front view, divide the pitch into several equal parts and divide the circle in the end view similarly. Then project the vertical and horizontal lines to find the intersecting points, through which draw the helix.

The common practice with such a screw when showing it in a machine drawing is to represent the threads as in Fig. 202. The light lines connect the tops of the threads, the heavy lines show the root of the thread.

SQUARE THREADS

If it is desired to draw a square thread screw with the helix correctly shown, follow the method of Fig. 203. Except for the fact that the thread here is square in section, the method is precisely the same as with the *V* thread in Fig. 200. After laying out the square form of the thread and thread space divide the pitch into a number of equal parts and using the same number of divisions for the circles in the end view, find the points of intersections of the horizontal and vertical lines from the division points and then draw the curve of the helix through the points of intersection. The layout, Fig. 203, shows the method with sufficient clearness so that there should be no difficulty in drawing the helix for both top and bottom of the thread.

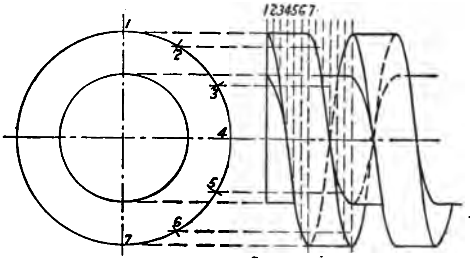


Fig. 203.—Single Square Thread—Right Hand.

In Fig. 204 a double square thread screw is shown of the same pitch as the single thread in Fig. 203. Lay this out and note the difference in the helix owing to the greater lead of the double thread.

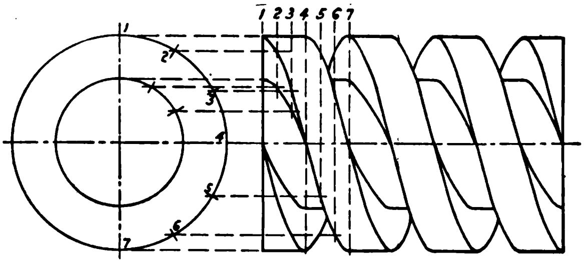


Fig. 204.—Double Square Thread.

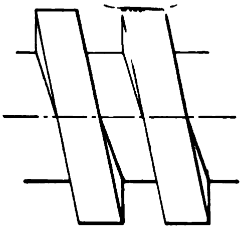


Fig. 205.—Conventional Method of Showing Square Thread.

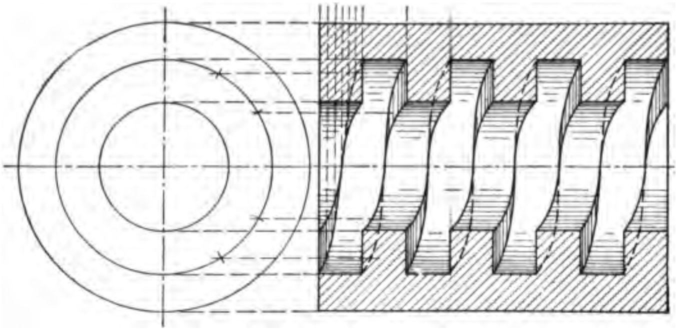


Fig. 206.—Square Thread Nut—Right Hand.

The conventional method of showing square threads is illustrated in Fig. 205.

In Fig. 206 a right-hand square thread nut is shown in section with the helix accurately drawn. The method is the same as for the square thread screw in Fig. 203. But as we are here looking at the rear side of the nut threads (the front half being cut away in the section) the slope of the helix is toward the right; or directly opposite that of the screw where we are looking at the *front* of the threads. The approximate or conventional method of drawing such a nut is seen in Fig. 207.

A quadruple thread is shown in Fig. 208. In drawing a screw like this with multiple threads take each thread separately as in Fig. 209, and note the characteristics of the helix as it curves around the core of the screw in making one complete revolution. Draw in the other threads and complete the screw as in Fig. 208. Then draw a helical groove around a cylinder as in Fig. 210. This might represent a special cam groove or it may be considered as a part of the multiple thread screw, Fig. 209. For it represents in the latter case the groove lying between two adjacent threads. The drawing, Fig. 210, is a very common detail in connection with machine work as it may represent the path of a cam roller or some other piece of mechanism where rotary motion must be translated into reciprocating or oscillating action.

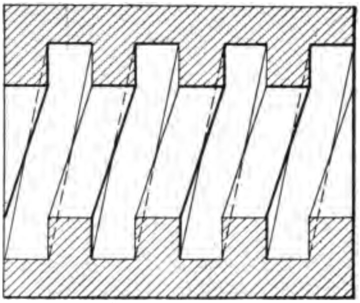


Fig. 207—Conventional Method of Showing Square Thread Nut in Section.

CUTTING SQUARE THREADS

The ability to lay out a square thread helix is very useful in respect to certain classes of tool work. While it is generally understood that the actual *cutting* of a *V* thread in the lathe must be accomplished with the threading tool set exactly on the center line of the lathe and work, it is not thoroughly appreciated that the position of the tool for a square thread has also a marked effect upon the shape of thread produced,

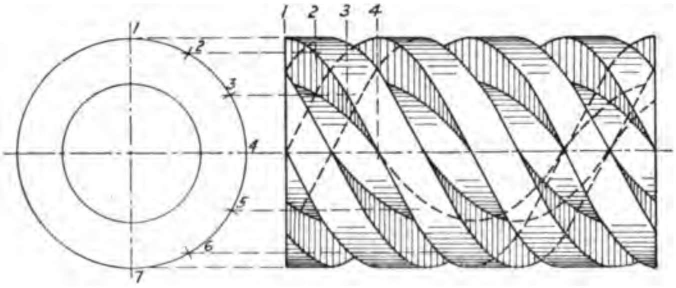


FIG. 208.—Quadruple Thread Screw, Square Thread—Right Hand.

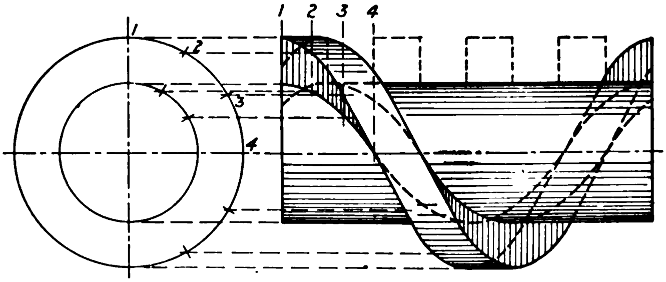


FIG. 209.—A Single Thread Corresponding in Lead to Quadruple Thread in Fig. 208.

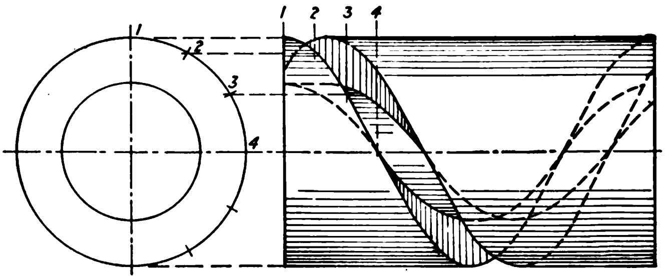


FIG. 210.—Single Groove Corresponding in Lead to Quadruple Thread in Fig. 208.

particularly when the thread is multiple and therefore of coarse lead. Refer to the illustrations Figs. 211 to 215. Here is a double thread, right hand. It is often proposed to cut such a thread with the front edge of the tool set at an angle from the horizontal as indicated by the line *L-L*. This would be setting the cutting edge normal (or at right angles) to the angle of helix. The mechanical advantage of this setting would

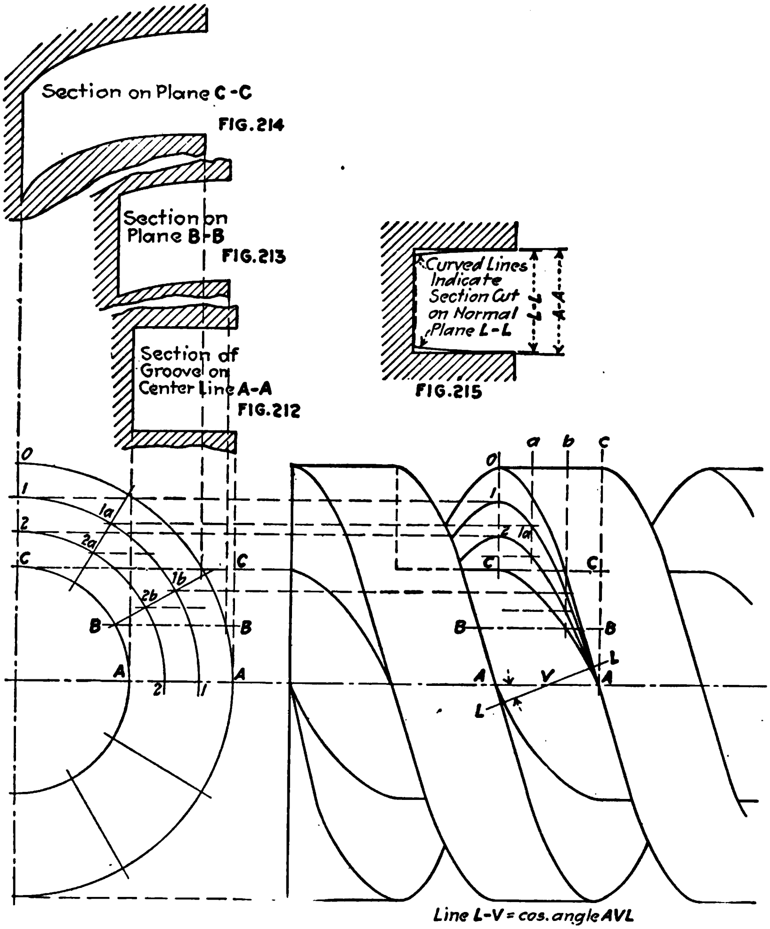

Section on Plane C-C
FIG.214
Section on Plane B-B
FIG.213
Section of Groove on Center Line A-A
FIG.212
Curved Lines Indicate Section Cut on Normal Plane L-L
FIG.215
a
b
c
O
1
2
C
1a
2a
1b
2b
B
A
2
1
V
L
Line L-V = cos. angle AVL

Fig. 211.—The Cutting of Square Threads.

be to give clearance to the leading side of the tool without excessive grinding away of its side face, and without producing excessive top rake on that side of the tool. At the same time it would eliminate the feature of negative rake on the right hand side of the tool or the obtuse corner which would tend to cut unsatisfactorily. But when we tilt the cutting edge of the tool to the position *L-L* we swing it out of the only plane in which it can produce a perfectly straight sided thread and moreover we produce a narrower groove than with the tool parallel to the centers.

By examination of section, Fig. 215, it will be seen that the sides of the thread groove, which are straight or perpendicular to the axis when cut on the center line, are slightly curved when sectioned on a plane normal to the path of the helix. Therefore this shape cannot be accurately reproduced by a straight sided square nose lathe tool tilted sidewise to bring its cutting edge in the normal plane or on line *L-L,* Fig. 211. Also the width of groove cut is narrower than standard by an amount equal to the difference between *AA* and *LL.*

Again examine the sections, Figs. 212, 213, 214: The first shows the straight side cut produced with the tool on the center line, and with its top perfectly parallel to the center line. Now suppose the tool is still kept in the horizontal plane but is lifted slightly above center as a square nose *cutting off tool* is sometimes set. In other words suppose it to be set on plane *B-B,* Fig. 211. The shape of the groove as cut with the tool on center line will be as indicated by the section, Fig. 213. Take the higher plane *C-C,* Fig. 211, and the curved side effect in the groove as cut with the thread tool on center will be as indicated in exaggerated form by Fig. 214. Due to setting the square thread tool otherwise than on the center line incorrect work will result. If the student will cut away the tops of the threads on a square thread screw of coarse pitch he will see the different shapes in the groove at different heights above the center.

Of course with threads of ordinary pitch the depth of groove is not sufficient to make a marked inaccuracy in the results if the tool is only slightly above center. But if the screw itself is slightly in error and a similar degree of error in the opposite direction is produced in the nut thread, there will always be difficulty in securing a proper fit between the two.

THE WORM THREAD

Another interesting example for the study of the helix is found in the worm thread, Figs. 216 and 217. The helix in Fig. 216 is drawn in the same manner as with the square threads described, except that the original section of the worm thread is formed with sloping sides as in Fig. 217. The latter section gives the proportions of this form of thread. The conventional method of showing the worm thread on a drawing is as in Fig. 18 where the external view is required. If the worm is shown

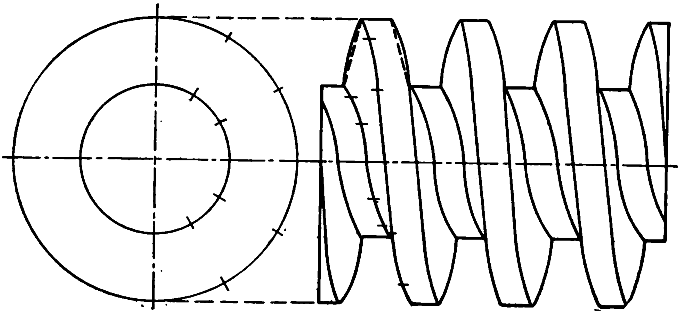


FIG. 216

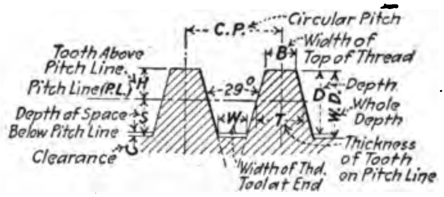


FIG. 217

The 29 Degree Worm Thread.

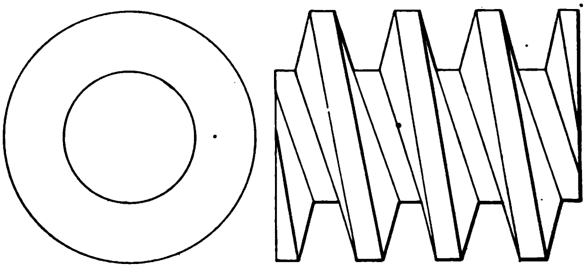


FIG. 218.—Methods of Showing Worm Thread.

as a longitudinal section the threads are represented as in Fig. 217. Further reference to screw and worm threads is made in other chapters in this book.

SPIRAL MILLING CUTTERS

Certain cutting tools are made with helical form of teeth which are commonly called spiral teeth. Thus the spiral milling cutter and the spiral reamer may be referred to as examples of this type of tool.

In Fig. 219 a spiral cutter is shown with twelve teeth, the diameter of the cutter being 2 inches. Such cutters are generally made with an angle of spiral or helix of 12 to 20 degrees, and in some cases the latter angle is exceeded by an appreciable percentage. In any case, however, the angle is very slight as compared with a screw thread and consequently the teeth make only a small part of a complete turn around the cutter. So each tooth presents only a portion of the helix and each tooth as drawn follows a different part of the curve of the helix. Therefore the laying out of such a cutter forms a very good example for practice on the board. In actual drawing room work, however, it is rarely the case that such a cutter is shown with the teeth in true helical form.

Referring to Fig. 219, it will be seen that at the left hand there is an end view of the cutter with the teeth drawn around the circle and numbered *T*-1 to *T*-12. At the right is an end view of the right-hand end of the cutter with similar tooth designations, but the first tooth, *T*-1, is shown moved to the left from the topmost position by an amount equal to two teeth. This angular change represents the distance around the circle which the angle of helix selected would carry the tooth for a cutter of the width given, or 3 inches. Now if we make a layout, Fig. 220, we can show an end view to the left showing the cutter teeth drawn in for the first three teeth, and dividing each tooth space into, say, three parts, we can then draw horizontal lines across from these divisions to the front elevation, the divisions then running 1, 2, 3, 4, 5, 6, 7. By dividing the width of the cutter into the same number of parts we have similar numbers 1′ to 7′ from which we draw vertical lines dividing the cutter face into six parts. Horizontal line 1 cuts vertical line 1′ at the upper left corner of the cutter layout. Horizontal line 2 cuts vertical line 2′ at 2*a*. Line 3 cuts line 3′ at 3*a* and so on to 7*a*, or the right hand end of the cutter. The curve drawn through the points of intersection, 1*a* to 7*a* forms the portion of the helix for tooth No. 1 in the cutter position represented.

The other teeth may be drawn in by the same process of finding the curve. It will be noticed that the width of land or top of the teeth varies from one end to the other and the cause will be apparent if the end view of the cutter is examined carefully. At the top of the cutter the flat land is in nearly a horizontal plane and the projection of this portion shows little width in the front elevation. As the tooth curves downward toward the center of the cutter body the width of land becomes more conspicuous and at the center line we see the width in its true dimension. For the face of the tooth where it is milled down to form the space between teeth, the true depth is seen only at that portion of the helix where the face is in the vertical plane as with tooth *T*-7 which reaches the vertical center line at the extreme right-hand end of the cutter.

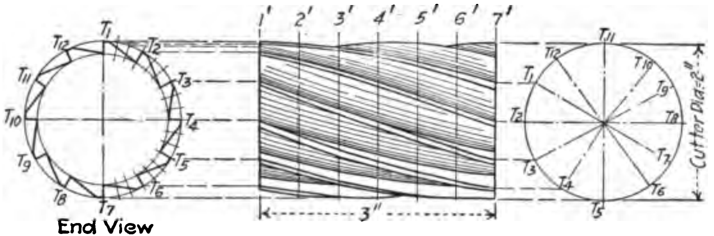


FIG. 219

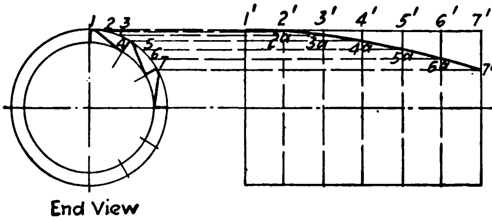


FIG. 220

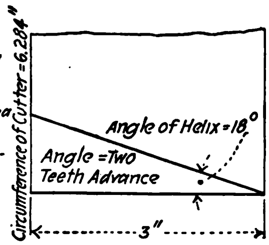


FIG. 221

Spiral Milling Cutter.

The diagram, Fig. 221, is merely to show the method of finding the angle of tooth by graphic layout. The vertical line at the left is part of the cutter circumference and on this is laid off a distance equal to two cutter teeth. Then a sloping line is drawn to the right-hand end of the base line and the angle formed by the two can now be measured.

TAPER REAMERS WITH SPIRAL TEETH

Fig. 222 shows a helical curve traced around a cone. The points in the curve will be understood from inspection of the two views. In this instance the front elevation is divided into

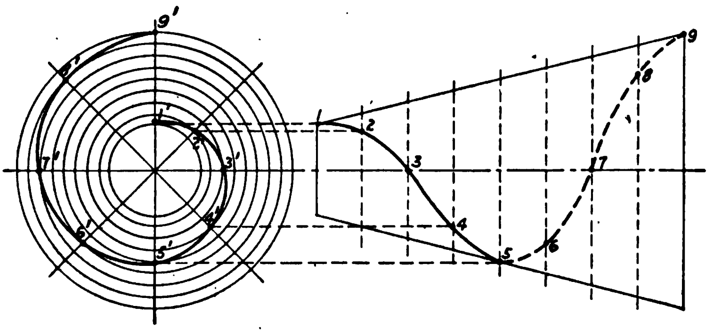


FIG. 222.—Helix on a Cone.

eight parts by vertical lines 1 to 9, 1 and 9 of course representing the ends of the piece. These lines cut the cone into a series of disks of different diameters and these diameters are transferred to the end view or plan where they appear as circles. These are divided radially by eight lines from the center. Starting with point 1′ on the first radial line and the smallest circle, we find point 2′ at the intersection of the second radial line with circle 2′. Point 3′ is at the intersection of the third radial line and circle 3′ and so on around the circle, until ending at 9′. Projecting horizontal lines from points 1′, 2′, 3′, etc., to the corresponding vertical lines on the front elevation we get points 1, 2, 3, 4, 5, 6, 7, 8, 9, through which we draw the helical curve around the cone.

An application of this curve is found in such tools as taper reamers with so-called spiral teeth. Fig. 223 shows such a reamer with 12 teeth. As this reamer is made with heavy taper the helical teeth are right hand to aid in pulling the tool into the work being reamed. With slight or moderate tapers it is customary to use a left-hand spiral to prevent the reamer from crowding itself into the hole too rapidly for safe and satisfactory results.

By studying the end view of the reamer in Fig. 223 it will be noticed that in this case the teeth advance (around the circle) from the back to the nose an amount equal to one tooth space. Divide this into, say, four parts by radial lines as 1, 2, 3, 4, 5, and divide the length of the reamer in the front elevation into the same number of parts. Transferring the diameters 2′, 3′, 4′, to the end view they appear as circles so that there are now five circles including the large and small ends of the reamer. Circle 1*a* and radial line 1 form an intersection for the first point in the curve of the tooth as seen in this end view. Circle 2*a* and radial line 2 intersect at 2*a* for the second point in the curve. Circle 3*a* and radial line 3 cut each other at point 3. Circle 4*a* and radial line 4 cross at point 4*a*. Circle 5*a* (the outer circle) and radial line 5 form the intersecting point for the outer end of the curve. This curve is transferred to the front elevation by dividing the length of the reamer as instructed, into four parts and then projecting horizontal lines from points 1*a*, 2*a*, 3*a*, 4*a*, 5*a*, to the corresponding vertical lines in the elevation at 1′, 2′, 3′, 4′, and 5′, the curve being drawn through these points of intersection at 1′ to 5′.

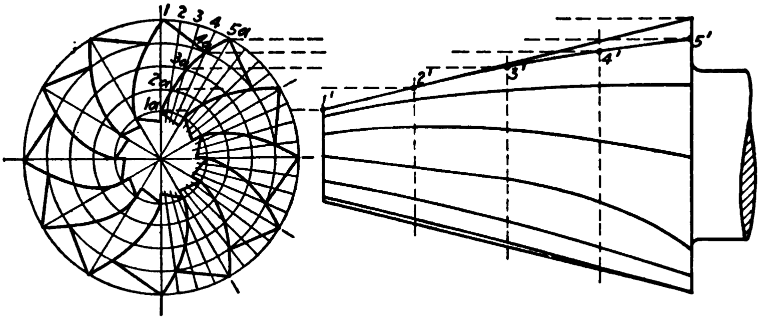


FIG. 223.—Taper Reamer with Spiral Teeth.

The curves of the other teeth are laid out in similar fashion.

CHAPTER VI

SCREW THREADS IN THEIR CONVENTIONAL FORMS

While it is not the purpose of this chapter to show all of the forms of screw threads and all bolts, nuts and screws in use in the shop, a number of the leading standards will be illustrated with certain data pertaining to proportions. For complete tables of all classes of threads, bolts and screws refer to the "American Machinists Handbook" where all dimensions are given for convenient use in the drawing office and machine shop.

In Figs. 224, 225 and 226 herewith three forms of threads are shown which are outlined here with formulas for their proportions. The first is the 60 degree sharp V thread; the second the United States Standard 60 degree thread with flatted top

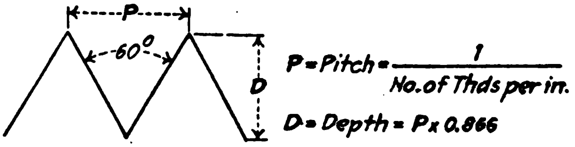


FIG. 224.—Sharp V-thread, 60°.

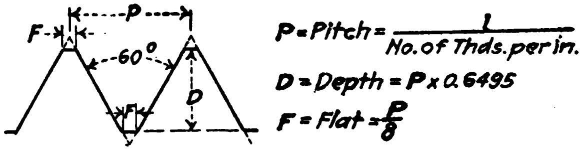


FIG. 225.—United States Standard Thread, 60°.

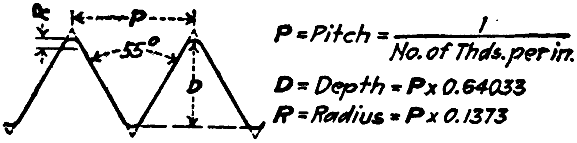


FIG. 226.—Whitworth Standard Thread.

and bottom equal to 1/8th of the pitch; the last the Whitworth Standard thread commonly used in Great Britain. This latter thread has an included angle of 55 degrees and is rounded at top and bottom to a radius equal to the pitch times 0.1373, the depth of thread being equal to the radius multiplied by 0.64033.

As pointed out in the preceding chapter, it is not usual to show the curve of the helix when drawing screw threads except in special instances. If we were to draw a bolt with the thread helix represented with fair accuracy it would appear something as in Fig. 227. Such showing of the threads is difficult and of no particular advantage ordinarily. If it is desired to approximate the helix within reasonable limits and still produce a thread in a reasonable length of time the simpler method is that of Fig. 228. Here again time is spent unnecessarily for the flats at top and bottom of the thread need not be drawn in with the additional connecting lines. If the thread is U. S. Standard it should be so marked but the showing of the flat is not required ordinarily.

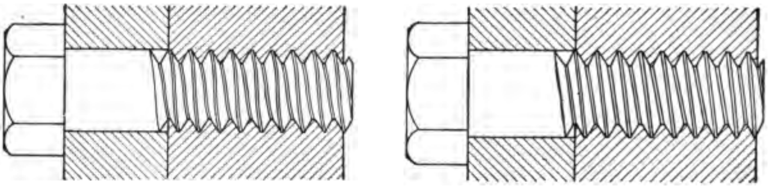


FIG. 227 FIG. 228

Bolts in Place.

COMMON METHODS OF SHOWING THREADS

In Fig. 229 various common methods of showing threads on bolts and screws are illustrated. One of the simplest and most desirable is the method at *A*. The lines are thrown at a slight angle to the perpendicular and the bottom of the thread is represented by the short heavy line while the top is shown by a light line. The method at *B* is somewhat similar, the heavy line here extending only half way across the screw diameter. The method at *C* is satisfactory where the screw or bolt is shown as a detail, but when it is assembled in some other machine part it sometimes leads to confusion owing to the resemblance of the inner end to a bushed member.

One of the very common methods of showing screw threads is that at *D*. The threads are drawn in free hand and unless one is very skillful at such work the result is ragged and anything but attractive. The method at *E* involves considerable effort without special advantages to offset the time and labor required. The sketch at *F* is to show the reversed slopes of lines for right and left hand threads.

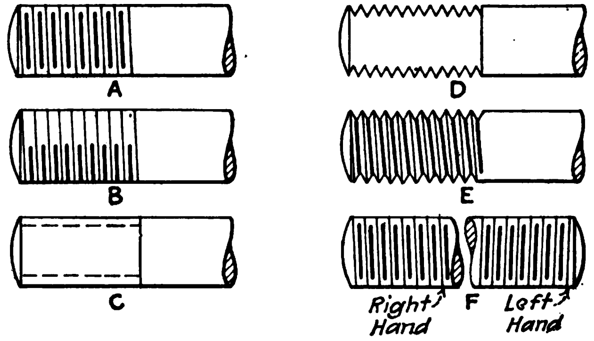


Fig. 229.—Methods of Showing Threads.

Tapped holes are also represented in a variety of ways in different drawing rooms. Fig. 230 shows three ways commonly followed where such holes are shown in plan view. Method *a* is perhaps the most common and it certainly can lead to little liability of error. Where a tapped hole is shown in a section or side view the methods *A* and *B* respectively are to be recommended. With a blind tapped hole, Fig. 232, the thread in the hole if in section is sloped in the opposite direction from the stud thread, as in *A*, Fig. 231, for it is the rear side of the tapped hole which we see when a nut is split.

BOLTS AND NUTS

Fig. 233 shows a U. S. Standard hexagon head bolt and nut in place in a machine frame. The diameter is designated as *D*. The head of the bolt, rough dimensions, that is, with unfinished surfaces, measures across flats (*A*) 1½ times the diameter, plus ⅛ inch. The distance across corners (*B*) is equal to *A* times 1.155. The head of the bolt is equal in thickness to one half *A* or the distance across flats. The thickness of the nut (*H*) is the same as the diameter of the bolt.

To lay out a hexagon nut or bolt head draw a circle equal in diameter to the distance across the corners. See *B*, Fig. 234. With the same radius as this circle step off the six points around the circle for the corners and draw in the hexagon form. A circle drawn inside the hexagon but just touching the flats represents the chamfer on the bolt or nut face. To draw the side or front view Fig. 234, lay off the width by projecting from the corners on the plan, and also draw in the width of the flat which is seen from the front of the nut. This gives the four corners, *a, b, c, d,* with one flat fully shown at the center while there are two foreshortened flats at the sides. Divide these latter flats in the center by vertical lines *f*. Set the compasses to a radius equal to one-half *B* and strike the arc for the top of the middle flat. Allow the compasses to swing across lines *f* and from the points of intersection draw in the small curves *gg* representing the tops of the flats at the sides.

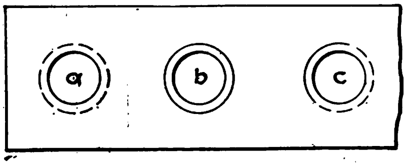


FIG. 230.—Holes Shown in Plan.

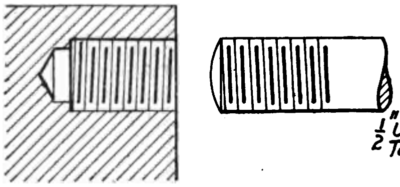


FIG. 232.—Blind Tapped Hole for Stud.

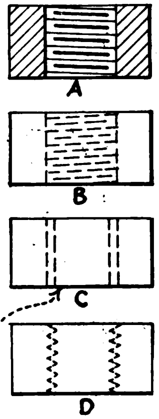
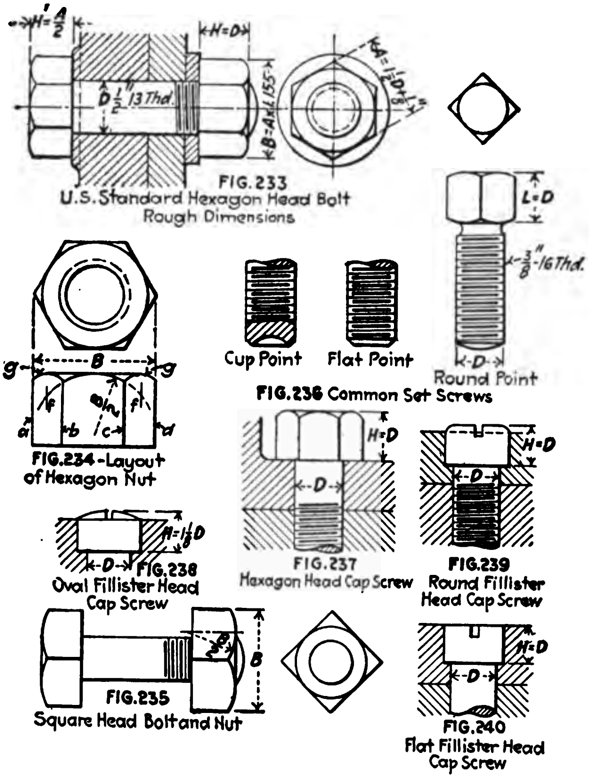


FIG. 231.—Tapped Holes in Side View and Section.

Fig. 235 shows a square head bolt and nut. The radius for the top of the nut is here one-half the distance across corners.

Fig. 236 represents a square head set screw with a number of regular points, including round, flat and cup points. The height of the set screw head is equal to the diameter of the screw.

Fig. 237 is a hexagon head cap screw. Figs. 238, 239 and 240 are fillister head cap screws, the first an oval head, the second a round head, the last a flat fillister head screw. Fig. 241 shows machine screws with fillister head, countersunk head and button head.

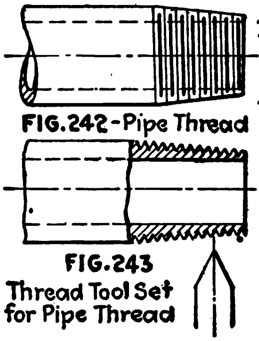


Bolt, Nut and Screw Proportions.

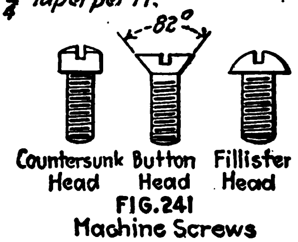
When showing screws and bolts the size and threads should be marked on the drawing as in Figs. 233 or 236, thus "1/2 in. 13 thd." or "3/8 in. 16 thd." Unless otherwise marked threads are always understood to be right hand.

MISCELLANEOUS THREADS

The pipe thread in Fig. 242 is known as the Briggs Standard and is formed on a taper of $^{1}/_{16}$ inch per inch or $^{3}/_{4}$ inch per foot. This thread may be shown on the drawing by the same class of lines as used for straight bolts and screws; see *A*, Fig. 229. This thread is cut square to the axis, that is with the thread tool set as in Fig. 243 with its axis at right angles to the center line of the work or the same as if the thread were to be cut on a bolt or straight screw.


Taper = 1/32" per in. on each side
or
1/16" Total Taper per in.
3/4" Taper per ft.
FIG.242-Pipe Thread
FIG.243
Thread Tool Set for Pipe Thread

Pipe Threads.



Machine Screw Heads.

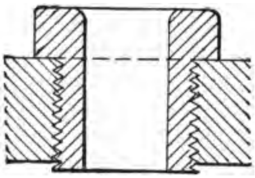


Fig. 244.—Threaded Bushing.

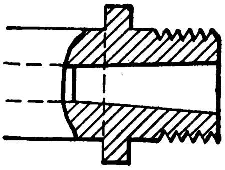


Fig. 245.—Spindle Nose.

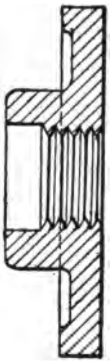


Fig. 246. Face Plate.

Although we can generally show standard screw threads satisfactorily by means of the simple lines at *A* or *B* in Fig. 229, there are numerous cases where special threaded machine parts can best be represented by showing the actual shape of the thread on the piece, particularly where the part is sectioned as in Figs. 244, 245, and 246. Fig. 244 is a threaded bushing such as might be used in certain classes of jigs. Fig. 245 is the front end of a lathe spindle, showing the threaded nose; Fig. 246 is a section through a face plate for a spindle like Fig. 245. In each instance the thread is clearly shown by the V-shaped outline.

CHAPTER VII

SHOWING DETAIL PARTS—SECTIONS

There are a number of different ways in which machine parts and tool details may be shown on the drawing board, and occasionally the manner in which such parts are drawn is anything but the best for clear interpretation upon the part of the mechanics who have to work from the drawings. The relative arrangement of the views, the question of external and sectional views, the incorporation of extra sections for hidden parts of the detail are all matters for careful consideration. The greater the familiarity of the draftsman with the details of shop operations, the clearer his conception will be as to what constitutes a clear, adequate showing of a given part on the drawing.

The present chapter is devoted to the illustration of a considerable number of parts with practical suggestions as to suitable methods of showing them in drawings. They are fairly representative of the wide variety of details coming under the draftsman's attention in ordinary practice and a little time devoted to these pages by the student will prove of real aid to him when later he takes up the making of regular shop drawings.

SHAFTS, SPINDLES, ETC.

In drawing short shafts like Fig. 247 it is all right to show the full length of the shaft. Where the shaft is long, it should be shown broken as in Fig. 248. This break allows the view to be closed up to any desired length on the drawing. Sometimes surface shading like Fig. 249 is used on drawings of shafts and similar parts. It is simpler to show the shaft unshaded and draw in an end view as in the preceding illustrations.

Fig. 250 is an arbor or mandrel with an inserted piece at the end for the center hole. In showing such work the end can be broken out to the center line and the parts shown by cross hatching. Another partial section is in Fig. 251 where a shaft is shown with a cap pinned to the end. Here the cap is shown in section, and this allows the reduced neck on the shaft to be shown in its hole in the cap.

Where an end of the shaft or spindle is squared as in Fig. 252 the best position of the square is as indicated so that two sides of the square are visible in the front view. Similarly with a square opening in the end of the piece as in Fig. 253, this representing a chuck wrench. The square is best shown with two flats toward the observer.

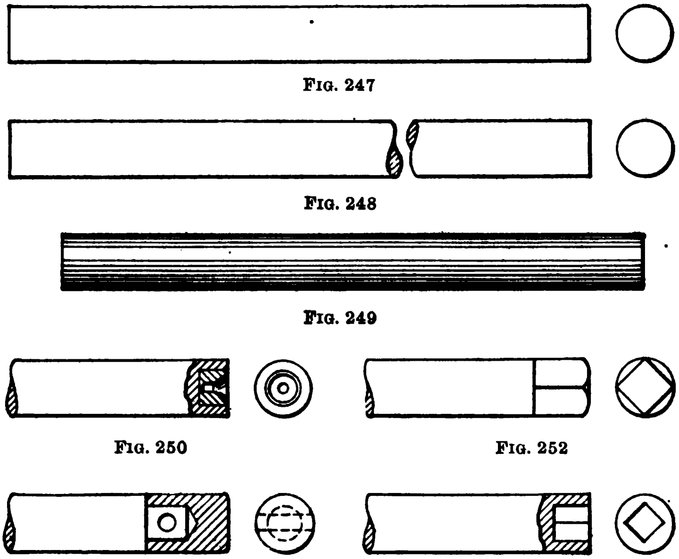


Fig. 247

Fig. 248

Fig. 249

Fig. 250

Fig. 252

Fig. 251

Fig. 253

Shafts, Spindles and Other Details.

Frequently shafts and spindles require oil holes or chambers through some portion of the metal. Two ways of showing such channels are presented in Figs. 254 and 255. Of the two the latter is preferable if for no other reason than that it allows the draftsman to note exactly the thickness of metal in the walls where the hole is drilled.

SLOTS AND KEYWAYS

Fig. 256 is a cutter bar with an elongated slot cut crosswise of the length. It is well to show three views of such a piece of work and the same is true of Fig. 257 which shows a shaft with keys inserted in longitudinal positions.

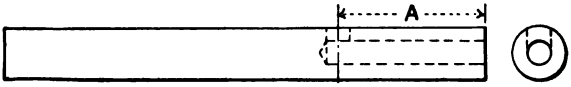


Fig. 254

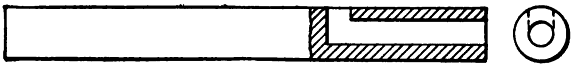


Fig. 255

Shafts with Oil Channels.

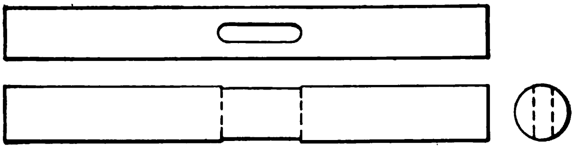


Fig. 256.—Boring Bar with Cutter Slot.

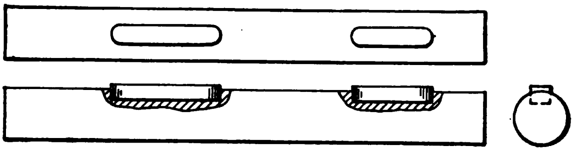


Fig. 257.—Shaft with Keys.

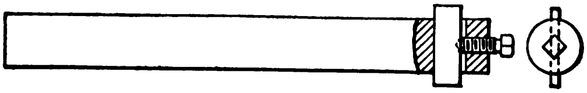


Fig. 258.—Boring Bar and Cutter.

Fig. 258 is a cutter bar with the boring cutter held at the end by a set screw. In this case the end of the bar is shown in partial section and the opening for the cutter and the seat for the screw are readily seen.

Two other keyway jobs are seen in Figs. 259 and 260. One of these, Fig. 259, carries the half round key; the other is fitted with taper key. In both cases the hub of the pulley or gear held on the shaft is shown in section and the shaft itself is partly sectioned in Fig. 259. It will be understood that all dimensions, key numbers, and other data are purposely omitted from these illustrations in order to show the details without confusion due to dimension lines, dimensions, and notes of one kind or another. When we come to the chapter on Working Drawings, complete dimensions will be found on all classes of parts.

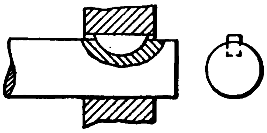


FIG. 259

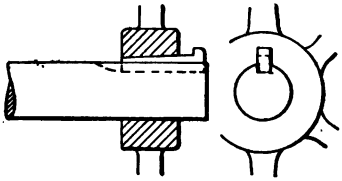


FIG. 260

Methods of Showing Keys in Shafts.

OTHER SPINDLES AND SHAFTS

Fig. 260 is a lathe spindle with taper hole at the front and straight hole clear through to the rear end. The front end of the spindle is shown in the side view broken away to a partial section thus revealing clearly the taper hole and the straight through hole.

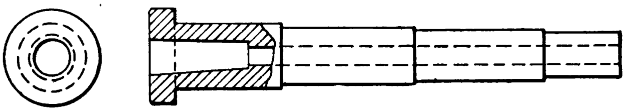


FIG. 261.—Showing Taper Hole in Spindle.

Fig. 262 is a shaft with several shoulders and Fig. 263 a roll with journal necks at each end. Such parts are always best shown as in these views except where they are hollow or built up of several members. Fig. 264 is included here to show an undesirable method of representing a roll like Fig. 263. When a member of this kind is shown by longitudinal section or partial section there is always a possibility of doubt as to its form whether round or other, and even with an end view there yet may be some chance of error in reading the drawing. Where the roll is made up of a hollow sleeve forced onto the central shaft, the sleeve or roll proper should be sectioned as in Fig. 265 and the shaft itself left in plain outline.

In Fig. 266 the drawing of the trunnion includes three views, the front elevation being really a partial section to show the thickness of the walls in the trunnion ring or body.

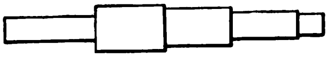


Fig. 262

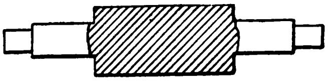


Fig. 264.—Not Good Practice.

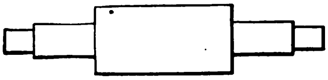
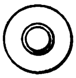


Fig. 263



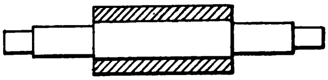


Fig. 265

Arbors and Shafts.

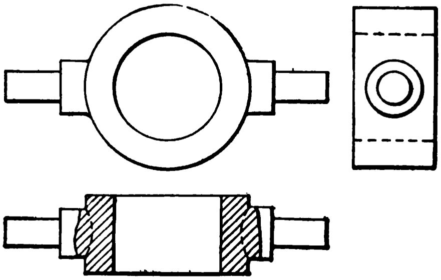


Fig. 266.—Trunnion.

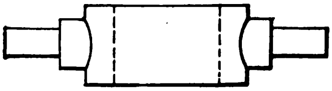


Fig. 267.—Trunnion Shown in this Manner May Possibly be Mistaken for a Roll.

This front view is sometimes drawn as in Fig. 267, as an external view, but there is the objection to this practice in that the piece may then be mistaken for some part like a heavy roll. Compare the view, Fig. 267, with the roll drawing Fig. 263. Aside from the dotted vertical lines in Fig. 267 there is nothing to indicate that the piece is a trunnion ring and not a plain roll. Of course the end view of the trunnion should make the real character of the piece apparent to any-body. But if possible each view of a part should be so drawn as to eliminate probability of misunderstanding, even though the rest of the views would naturally prevent such error.

BEARINGS AND BUSHINGS

Figs. 268 to 282 illustrate various types of bearing boxes and a number of different bushings. The box or sleeve in Fig. 268 is shown as a longitudinal section which is to be preferred to the outside view of Fig. 269. One can grasp the proportions of the metal in the walls and around the bore, and the depth of clearance chambers better by examination of the sectional view than when studying the external elevation in Fig. 269 where the interior form is shown only by dotted lines.

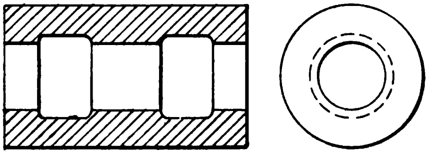


Fig. 268.—Preferable to Fig. 269.

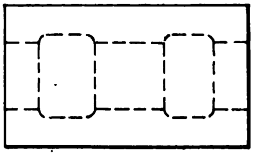


Fig. 269

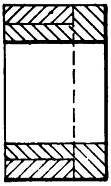


Fig. 270

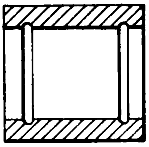


Fig. 271

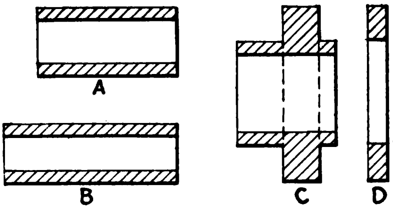


Fig. 272

Bearings and Bushings.

Similarly the bushings and sleeves in Figs. 270 to 274 are best shown as sections. In fact where longitudinal sections are so made in the drawing the end view can very often be omitted as it is generally understood that where only a longitudinal section is shown the work is round (like a disk) or cylindrical.

Fig. 275 is a plain bushing represented by two views. Suppose we are drawing a split bushing of the same proportions. The two parts may be drawn as *A* and *B*, Fig. 276, or they may be shown as in Fig. 277. With the arrangement of Fig. 276

there can be no chance of error in reading the drawing. With the bushing turned to the position in Fig. 277 there is an opportunity for the drawing to be understood as showing a solid bushing instead of one made in halves.

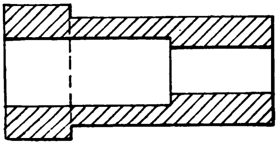


Fig. 273.—Bushing in Section.

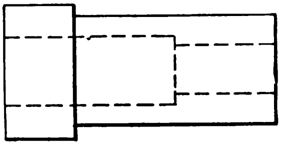


Fig. 274.—Bushing Shown Externally.

Another interesting detail for consideration is the sleeve of the general type in Figs. 278, 279, and 280. Fig. 278 includes a vertical section on the center line and shows outer and center walls satisfactorily. Fig. 279 shows a construction with a small boss on one side of the center web and this is best represented when drawing it, by considering it to be split along the dotted line *a-b*. This shows therefore a section through the side walls and also shows the location and size of the boss accurately. Fig. 280 represents a casting with a bottom wall and with the same web in the middle as in the former illustrations. This is naturally shown on the drawing by the vertical section through

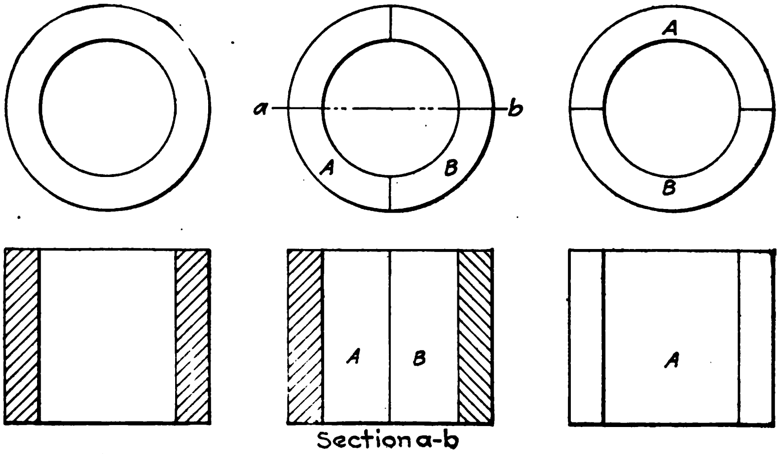


Fig. 275 Fig. 276 Fig. 277

Methods of Showing Bushing.

the center which gives a clear view of the thickness of all three walls and of the bottom as well.

Two bushings are seen in Fig. 281, one reduced and set into the enlarged bore of the other. With the longitudinal section

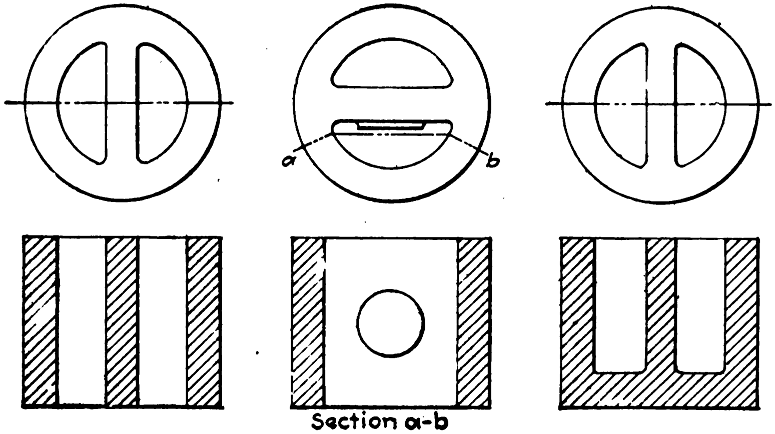


FIG. 278 FIG. 279 FIG. 280

Methods of Showing Sections.

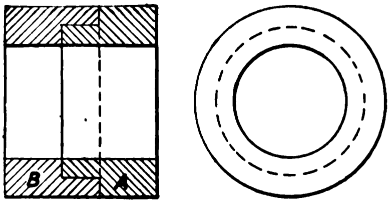


FIG. 281.—Section through Two Bushings Fitted Together.

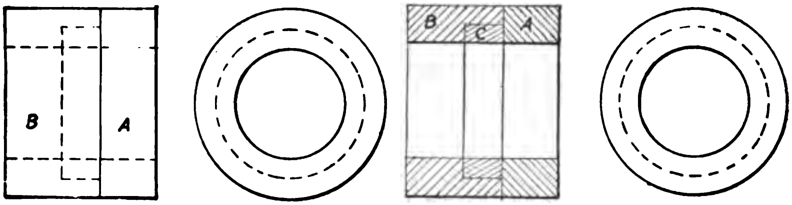


FIG. 282 FIG. 283

A Possible Interpretation of Fig. 282.

shown as in this drawing there can be no possibility of error in reading the drawing. The parts might be shown as in Fig. 282 as external views only. But with this method there is no guarantee that the drawing will not be misread and the parts actually made, as in Fig. 282, where there are three pieces instead of two. That is, the reduced portion of bushing *A*, may, in the dotted elevation, Fig. 282, be mistaken for a third part such as a narrow ring *C*, Fig. 283. No such chance for error exists in the drawing Fig. 281.

PULLEYS AND COUPLINGS

Fig. 284 represents a pulley with six arms. With pulleys having arms it is customary to show a section through the center with the imaginary splitting plane passed between two arms, as indicated by line *a-b*. When the pulley has a solid web instead of arms the section is made as in Fig. 285. The plan of the pulley if of appreciable size is usually of only a portion of the rim. The hub and bore must be shown but the arms at one side may be broken off in the plan so that the two views may be placed closely together, thus saving space on the drawing.

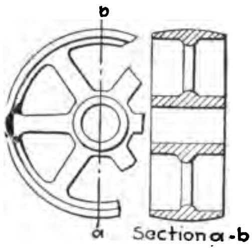


Fig. 284

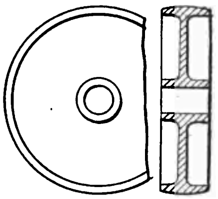


Fig. 285

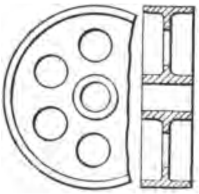


Fig. 286

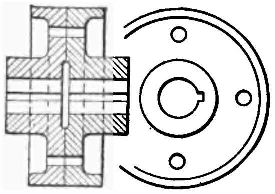


Fig. 287

Pulleys and Couplings.

Where the pulley has a web with a series of holes through it as in Fig. 286 the sectional view is usually made to cut through the openings at each side of the hub as shown in the illustration.

Fig. 287 is a coupling where the two halves are shown in section, the parts being section lined in opposite directions. The keyway is seen at the back of the bore in the section.

LEVERS AND CAMS

These parts may be referred to briefly in order to point out one or two considerations in the placing of views. Thus Figs. 288 and 289 show a certain lever in plan and elevation.

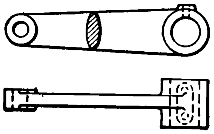


Fig. 288.—Lever.

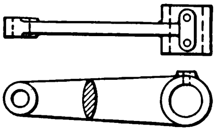


Fig. 289.—Preferred to Fig. 288.

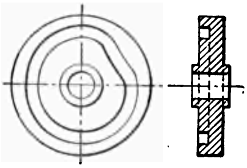


Fig. 290.—Cam.

This lever has an elongated boss on the large end to provide space for two oil holes. With the arrangement of views in Fig. 288 the boss referred to is necessarily indicated by dotted lines for it comes at the rear side of the lever as seen in elevation. However, by changing the relative position of the plan and elevation to that in Fig. 289 the boss and its oil holes are brought to the front side where they are distinctly shown.

The cam in Fig. 290 is a face cam with a roll groove milled around the face. The section given cuts the cam casting through the center and shows the form of the cam groove clearly.

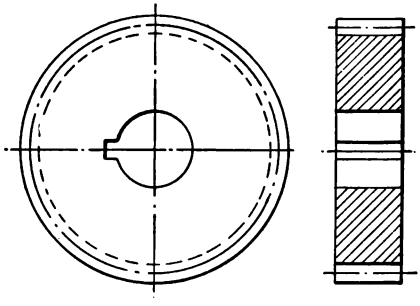


Fig. 291.—Plain Gear.

GEARS

The common method of showing a solid spur gear is represented in Fig. 291. The three circles on the plan are outside diameter, pitch diameter and root diameter.

Where the gear is made with arms the method of showing in the drawing is as in Fig. 292, the section here coming between the arms as with the pulleys referred to previously.

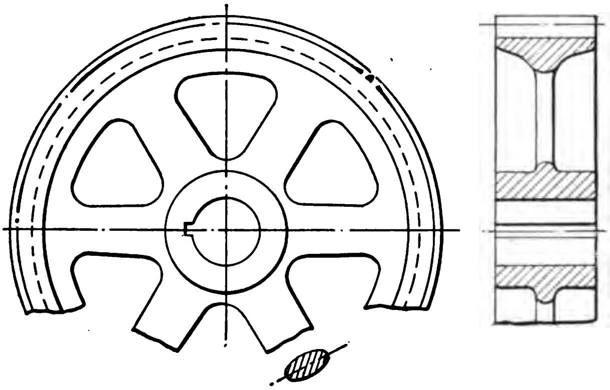
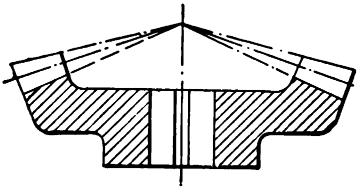


FIG. 292.—Gear Wheel with Arms.

A bevel gear is usually shown as in Fig. 293 with a sectional view only unless it forms some part of an assembly drawing where more than one view is necessary. The worm and worm gear is shown in section in Fig. 294.



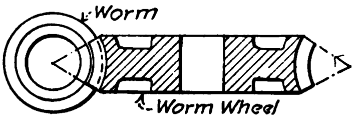


FIG. 293.—Bevel Gear. FIG. 294.—Worm Gear and Worm.

LAYING OUT A SPUR GEAR

It is not intended here to enter into a description of the methods of laying out gear teeth of all classes. For this special phase of drawing board operations the reader should refer to the "American Machinist's Handbook," and the "American Machinist's Gear Book," where complete data for all kinds of gear layouts will be found.

A brief description however will be given here of a spur gear layout for practice for the student. Say we have a spur gear, Fig. 295, where all dimensions are as given. After drawing the blank in accord with the illustration herewith, the teeth may be laid out as in Fig. 296. This gear is supposed to be made to the B. & S. involute system.

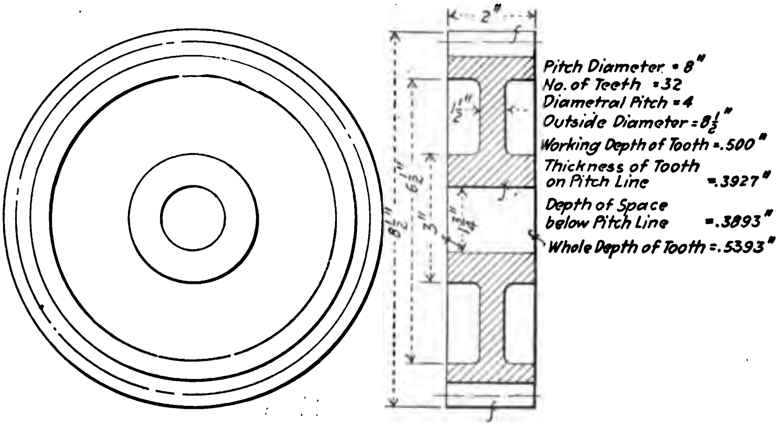

2"
$1\frac{1}{2}$"
$8\frac{1}{2}$"
$6\frac{1}{2}$"
3"
$1\frac{3}{4}$"
f
Pitch Diameter = 8"
No. of Teeth = 32
Diametral Pitch = 4
Outside Diameter = $8\frac{1}{2}$"
Working Depth of Tooth = .500"
Thickness of Tooth on Pitch Line = .3927"
Depth of Space below Pitch Line = .3893"
Whole Depth of Tooth = .5393"

Fig. 295.—Drawing of Spur Gear.

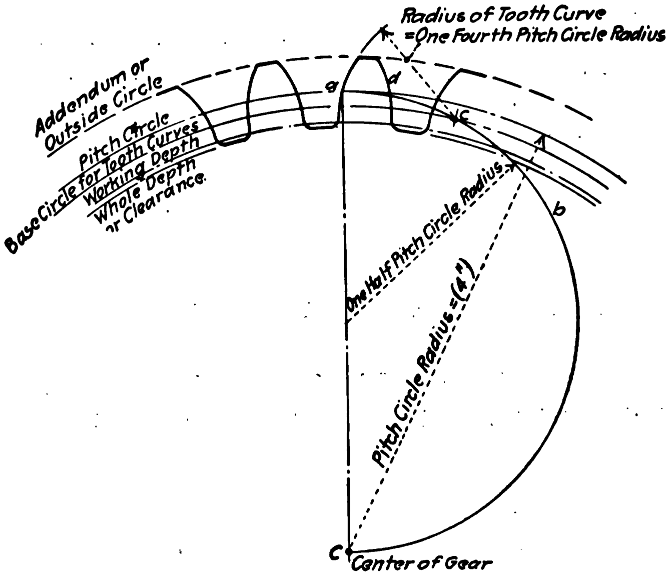

Radius of Tooth Curve =One Fourth Pitch Circle Radius
Addendum or Outside Circle
Pitch Circle
Base Circle for Tooth Curves
Working Depth
Whole Depth or Clearance
a
d
c
b
One Half Pitch Circle Radius
Pitch Circle Radius =(4")
C
Center of Gear

Fig. 296.—Method of Laying Out Involute Gear Tooth Curve.

First, draw part of a circle say one-third or one-quarter, to a radius of the pitch circle as given in Fig. 295. This pitch diameter is there given as 8 inches so the pitch circle radius of Fig. 296 will be one-half or 4 inches. Then divide the pitch circle radius by two, getting 2 inches as the radius for a new setting of the compasses with which we strike a semicircle from the center of the layout to the pitch circle where the circles touch at point *a*. Set the compasses now to one-fourth the pitch circle radius, or 1 inch, and from point *a* sweep an arc across the semicircle *b* which it cuts at point *c*. Then with radius equal to *C-c* draw the circle through point *c* representing the base circle for tooth curves. Now with radius equal to *a-c* and with the compass point set at center *c* strike an arc *a* which will be one side of the gear tooth. The thickness of the tooth having already been laid off on the pitch line, strike a similar arc from the opposite side and thus form curve *d* representing the other side of the tooth.

HANDWHEELS AND HANDLES

Handwheels and handles are machine parts commonly required to be shown on drawings. A typical handwheel is seen in Fig. 297. This has four arms and a part section is given cutting through the hub from the front and then cutting the rim through the center of the tapped hole for the handle. The cutting plane is assumed as coming in front of the arm so that is left without sectioning in the side view, but in the front view two cross-sections are given through the arm to show the actual shape of the metal at those points.

The crank handles in Figs. 298 and 299 are shown as part sections to give an idea of the method of securing the handles in place.

HIDDEN SECTIONS OR DOTTED SECTIONS

Sometimes it is desired to bring out a section of some hidden part of the casting or other piece without breaking out a section on the drawing. A full outside view may be desired and yet it may be required to include in that same view a clear representation of some rib, wall or web which comes inside of the body, or at the rear. Fig. 300 is an illustration of this general character where a casting is represented with the end view drawn in fully but with the cross section also added to the view by the simple device of using a dotted cross

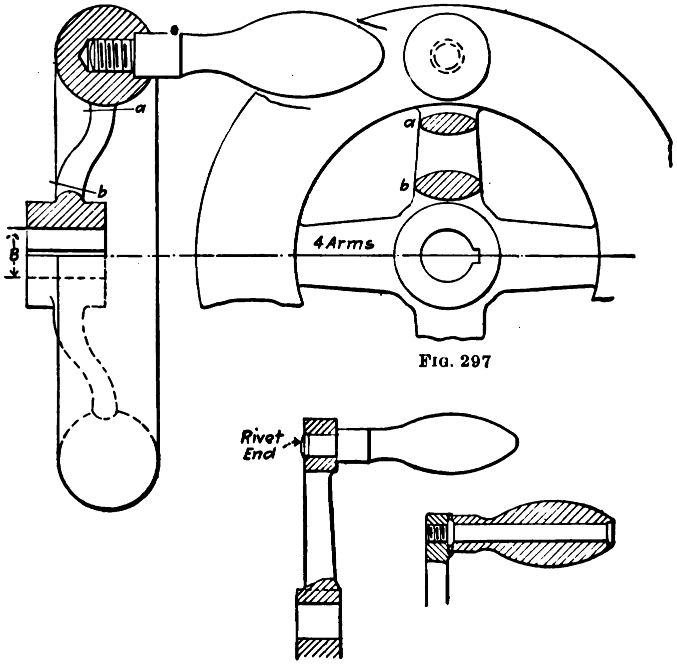


Fig. 297

Fig. 298 Fig. 299

Hand Wheels and Handles.

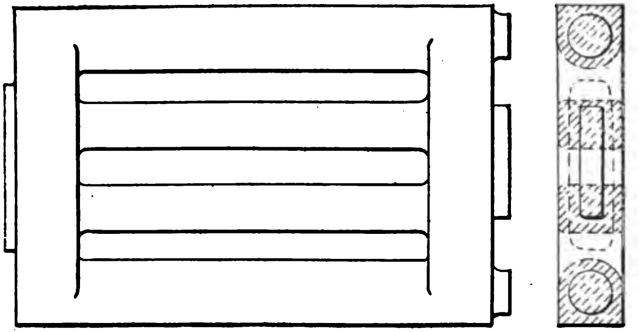


Fig. 300.—Hidden Section or Dotted Section.

hatching. Fig. 301 shows another drawing of similar type. Here a small cylinder behind the main cylinder bore has its walls brought out by dotted hatching. The main cylinder is itself shown as an actual section by full line cross hatching. Thus we have here a case of one section behind another.

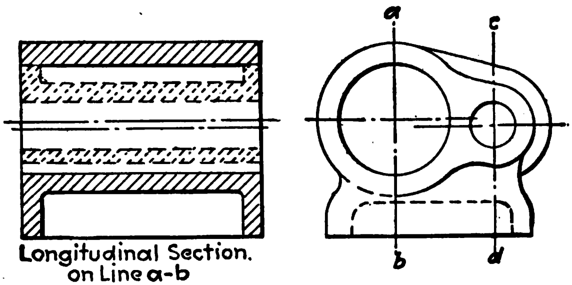


Fig. 301.—Sections on Two Planes.

OTHER MACHINE PARTS

The drawing in of screw heads on a plan view of a machine or detail of a machine is a little matter to which attention may be called as one thing where position is selected for the sake of neatness. Thus refer to Fig. 302 and note the neat effect produced by showing the slots in the fillister heads

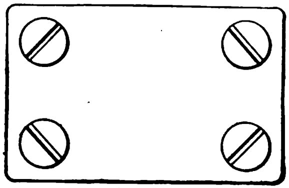


FIG.302

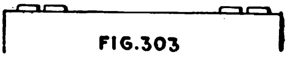


FIG.303

Showing Screw Heads

drawn at an angle of 45 degrees to the center line of the work. The slopes for opposite screw heads is in opposite directions. In the elevation, Fig. 303, such screw slots are shown in central position. This is a little illogical from the point of view of accuracy but as a matter of fact the angular position of any screw slot when set into the machine depends entirely upon the degree to which the screw is tightened.

Therefore the position in which such slots appear on the drawing is entirely a matter of appearance.

PINNED JOINTS

In Fig. 304 we have what is known as a "Dutchman" for holding a part on a thread by means of a straight pin driven in from the end. The hole for the pin is so drilled that one-half comes in the screw portion and the other in the knob. The knob is supposed to be screwed tightly in place before the pin hole is drilled.

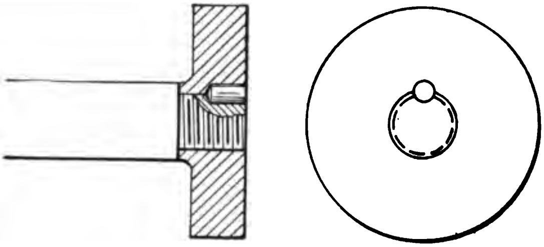


Fig. 304

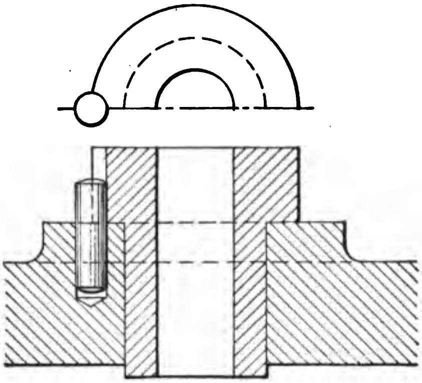


Fig. 306

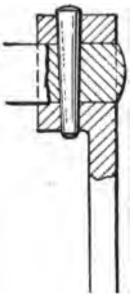


Fig. 305

Fastening Pins.

The showing of the partial section or broken section through the outer end of the thread gives an opportunity to show at the same time the exact position of the pin in respect to both of the main members.

A taper pin through the crank handle and shaft in Fig. 305 is best shown by breaking out a section and drawing in the pin in full lines while the adjacent portions of the crank and shaft are cross hatched.

The straight pin for holding the bush in the jig in Fig. 306 is shown in the same fashion. The bush and jig are both shown in section and the pin in its external form.

TOOL PARTS

Figs. 307, 308 and 309 are bushings with knurled heads, such as slip bushings for a jig. Of the three methods of showing such a bushing the neatest is that of Fig. 307. On the other hand the most satisfactory from all practical points of view is that in Fig. 309 which gives at once the section through the wall of the bushing, shows the hole clear through and also shows enough of the knurled head to answer every purpose.

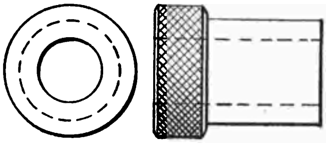


Fig. 307

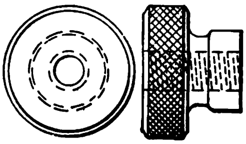


Fig. 310

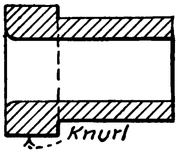


Fig. 308

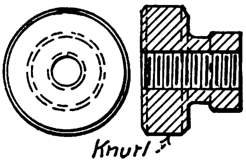


Fig. 311

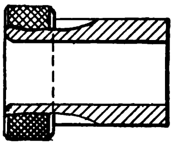


Fig. 309

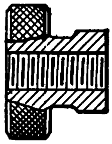


Fig. 312

Methods of Showing Knurled Bushings and Nuts.

The three methods of showing a knurled head nut in Figs. 310, 311, and 312 are comparable to the three views of the bushing and Fig. 312 is the one to be preferred under most circumstances.

Figs. 313 and 314 represent the usual method of showing a plug and ring gage. Where the gage is quite large as in Fig. 315 most of the work of drawing in the knurled effect is avoided by simply showing a small knurled area near one corner and marking the word "Knurl" on the handle as indicated.

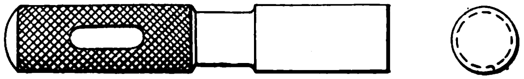


Fig. 313.—Plug Gage.

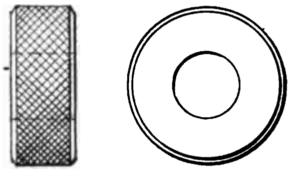


Fig. 314.—Ring Gage.

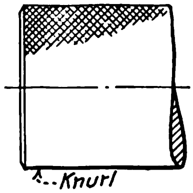


Fig. 315.—Indicated Knurling on Large Handle.

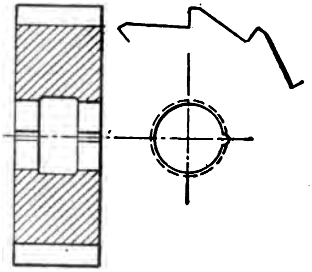


Fig. 316

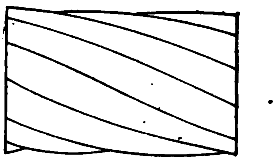


Fig. 317

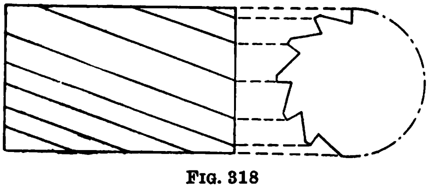


Fig. 318

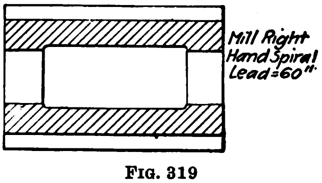


Fig. 319

Milling Cutter.

MILLING CUTTERS

The conventional method of drawing a milling cutter is represented by Fig. 316. This gives a section through the cutter body and between the teeth and the side view shows a few teeth on which all dimensions for cutting may be placed.

Fig. 317 is a close approximation to the curved teeth of a spiral milling cutter while Fig. 318 shows the common method of actually putting such a cutter on the drawing paper. Oftentimes the curve of the teeth is entirely omitted and instead a section is given longitudinally as in Fig. 319 which is marked to convey the requisite information for the making of the proper helix on the cutter. Thus note the instruction "Mill Right Hand Spiral. Lead equals 60 inches."

For full data on sizes and proportions of machine and tool parts referred to in this chapter see following sections in "American Machinists' Handbook," Third Edition:

Keys and Keyseats, pages 375-386; Spindle Tapers, pages 392-402; Gearing, pages 101-150; Shop and Drawing Room Standards, pages 428-466; Milling and Milling Cutters, pages 151-218.

CHAPTER VIII

PARTS AND SECTIONS IN ASSEMBLY DRAWINGS

An assembly drawing may show an entire machine or it may be a drawing of an assembled mechanism forming but a group of parts in the complete machine. In any case its purpose is to show the relationship between different members in the unit and owing to the number of parts usually included in such a drawing it is as a rule a rather difficult piece of work for the young draftsman who attempts to make the most satisfactory showing of the various parts in the construction.

We have already taken up in Chapter VII some of the customary methods of showing in drawings a variety of machine and other details. A number of illustrations are presented in this chapter to bring out certain features of practice in connection with assembly drawings; such as the general arrangement of the views, the sectioning of different parts adjacent to one another, and so forth.

CROSS-SECTIONS FOR METALS

Fig. 320 illustrates some of the common cross-sections for metals such as cast iron, wrought iron, brass, etc. There is no complete standardization of cross-sections in our drawing rooms though certain standards have been proposed for general adoption. However the sections here shown for cast iron, brass, babbitt and copper are quite generally followed. Many drawing offices use only the one cross hatching, that is the plain one shown here for cast iron. In such cases the name of the material is marked on the part itself and there is therefore no chance of confusion under such a system.

In Fig. 321 a section is shown through a slide, guide and a pair of gibs. The section lining or cross hatching is ruled in at 45 degrees, and so far as possible the ruling is in opposite directions for adjoining surfaces. With the gibs *A*,*A*, however, which are adjacent to two different members we have to choose between making the slope of cross hatching at a different angle

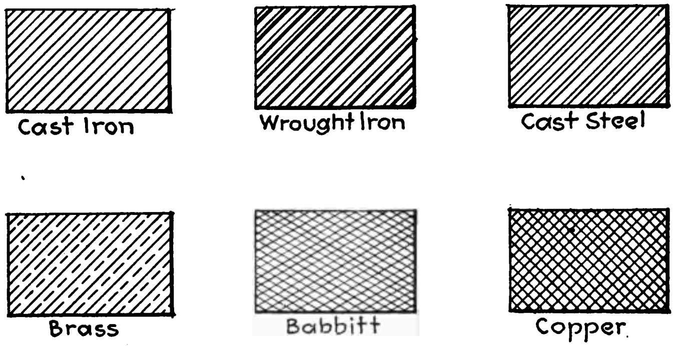


FIG. 320.—Cross-sections for Different Materials.

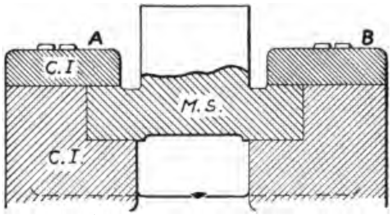


FIG. 321.—Cross Hatching where Several Parts are in Contact.

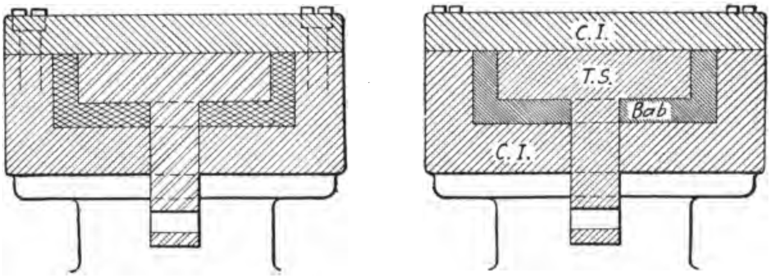


FIG. 322 FIG. 323

Methods of Cross Hatching a Slide and Guide.

from 45 degrees or using a finer spacing between lines. The latter practice is the better as the 60 degree angle sometimes employed does not present as neat and distinctive a section lining as the closer spaced ruling here used.

In Fig. 322 another section is shown through a slide and guide the sliding member in this instance being carried in a babbitt seat. The cross-sections here used correspond with the standards of Fig. 320. Fig. 323 shows the same piece of mechanism but here a single line section is used for all metals with the kind of material indicated by abbreviations. C. I. for cast iron; T. S. for tool steel; Bab. for babbitt metal.

Figs. 324 and 325 are similarly illustrative of a spindle journal and box, in the one view the cross hatching being according to the standards of Fig. 320 while the latter drawing

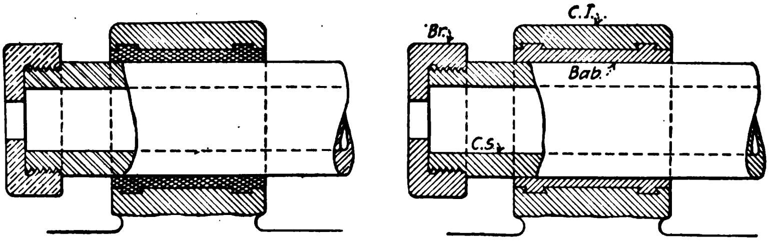


Fig. 324 Fig. 325

Cross Hatching of Spindle Boxes

shows the single line cross hatching with the material designated on each part.

ASSEMBLY VIEWS

While it is desirable to have complete assembly drawings of a machine they are often not made in more elaborate form than a mere outline with general center distances established and a few other important features set off for reference in working up details. Sometimes certain features such as heads, gear boxes, and other groups of mechanism are drawn up as assemblies by themselves but without a complete layout of the entire piece of machinery. This is especially true where a machine is of new design and subject to considerable experimental work with consequent modification before its permanent design is fixed upon.

Again, a certain assembly view may be necessary for shop and drawing room purposes and this one view may answer the needs of the moment without causing delay in getting out complete plans, elevations, and cross and longitudinal sections.

Frequently a certain cross-section through a machine may serve to disclose all of the essential points and for the time at least the completion of full assembly views is postponed.

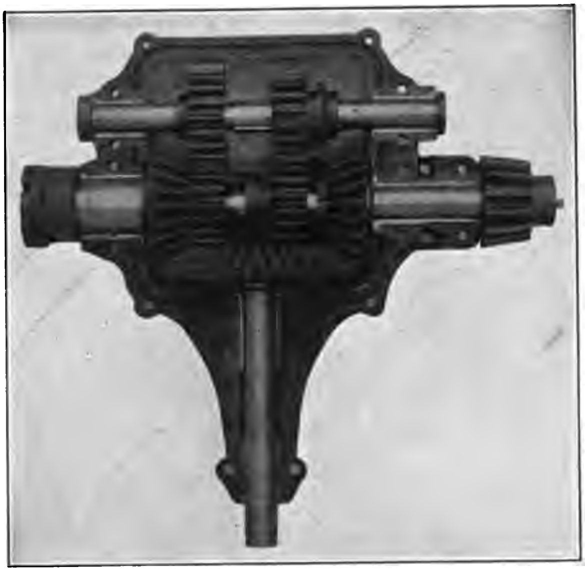


FIG. 326.—Two-speed Transmission.

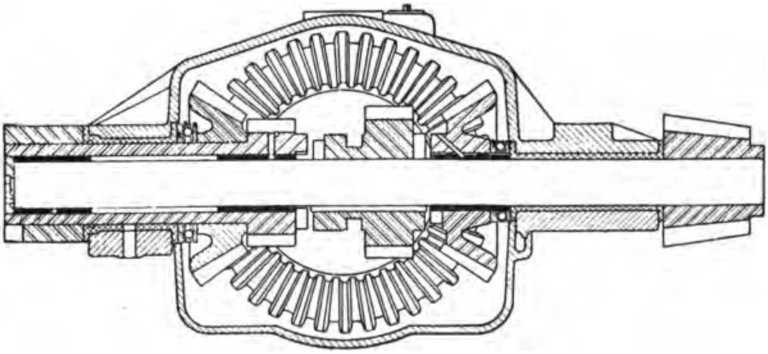


FIG. 327.—Longitudinal Section through Two-speed Transmission Shown in Plan in Fig. 326.

Fig. 326 is reproduced from a photograph of a two-speed transmission for a tractor. A complete assembly drawing of this unit would include a plan view of the mechanism, a longitudinal section in the horizontal plane common to all of the shafts, a vertical section along the center line of the main cross shaft and one or more cross-sections. But for specific purposes such for example as showing the arrangement of the main shaft bearings, the thrust bearings for the bevel pinions, etc., the one assembly view in Fig. 327 will suffice. This is an excellent drawing of a gear mechanism with all parts about the shaft properly section lined.

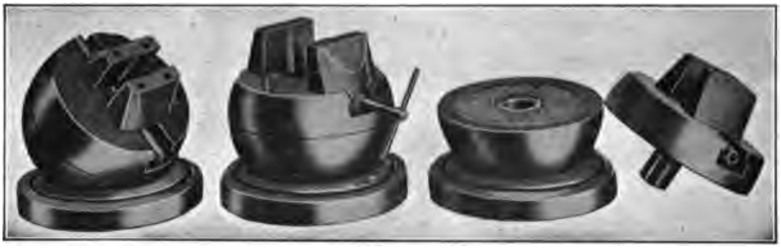


FIG. 328.—Universal Ball Vise.

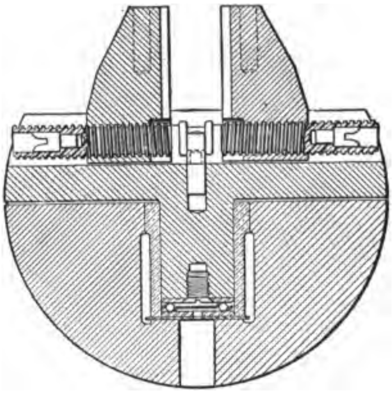


FIG. 329.—Vertical Section through Ball Vise Shown in Fig. 328.

A BALL VISE

Fig. 328 illustrates a universal ball vise which may be set to any angle in any plane so that work held in the jaws may be brought to the most convenient position for the toolmaker at the bench. The purpose of an assembly drawing for this vise is to show the manner in which the screws act upon the jaws, to open and close them in their guide, and the method of mounting the stem of the revolving table in a bushed bearing in the base and supporting it upon a ball thrust bearing.

Fig. 329 therefore is a vertical section showing the assembled vise as it would appear if cut from top to bottom through the center of the jaws, spindle and spherical base.

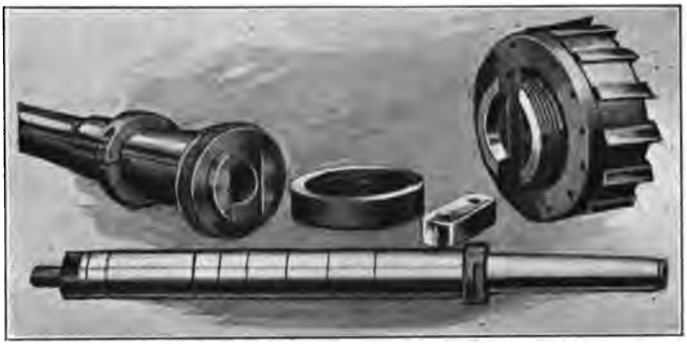


FIG. 330.—Details of Milling Machine Spindle.

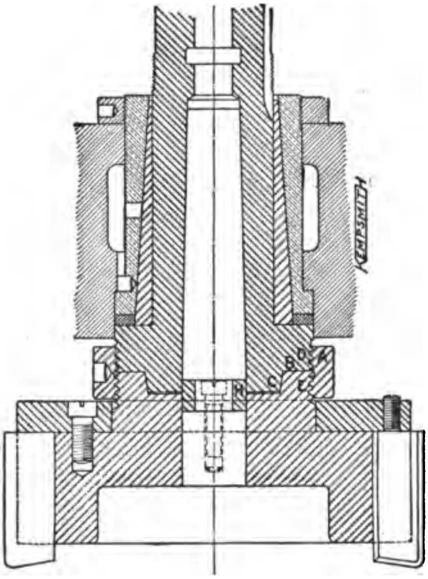


FIG. 331.—Section through Milling Machine Spindle and Cutter.

A MILLER SPINDLE ASSEMBLY

In Fig. 330 a group of milling machine parts is shown. These are the spindle, with special form of nose, a cutter driving key, which fits crosswise of spindle and cutter in a slot milled in each, a large face milling cutter, and a threaded collar for screwing over spindle nose and cutter hub.

A vertical section showing how these parts assemble together is reproduced in Fig. 331. This one view not only illustrates the assembly of the members already referred to but also shows the taper spindle box which fits in a taper hole in a sleeve that is drawn up into place in its seat in the miller head by means of a nut at the upper end. Here is another neat example of section lining on a number of parts.

SHAFT HANGER

The assembly drawing in Fig. 332 represents a ball bearing line shaft hanger. Three views are here given on the drawing. The plan shows the overall dimensions of the top or foot, with center distances between the bolt holes. The front elevation shows the entire hanger with a partial section at the bearing to illustrate the ball races. The third view is a vertical section through the center of hanger and ball bearing, including arrangement of supporting screws and nuts by which the bearing is carried in the hanger frame and adapted to be self-aligning.

A CROSS SLIDE TAIL STOCK

The assembly drawing, Fig. 333, shows four views of a cross slide foot stock for the bench lathe. This drawing includes a plan view, an elevation of the end, and two sectional views. The foot stock is made in two main parts, *A* and *B*. The lower member *A* is clamped to the bench lathe bed by two binders *C*. The upper part *B* is free to travel in the guide formed in the upper face of lower casting *A*. The amount of travel is limited by the stop screws *D* and the motion forward or backward is controlled by the handle *E* and the screw *F*. The casting *B* carries the spindle *G* which is operated by the handle *H* and the screw *I*. The spindle is bored out to receive standard taper shank boring or cutting tools and is limited in its movement by the dog *J*, which carries the stop screw *K*. Both handles *E* and *H* have graduated disks or collars *L* and *M* respectively keyed to turn with the handles.

Note the method of showing the different parts in section by means of 45 degree section lining. Also note the way in which all screws are represented by the slightly sloped lines light and heavy for the tops and bottoms of the threads respectively.

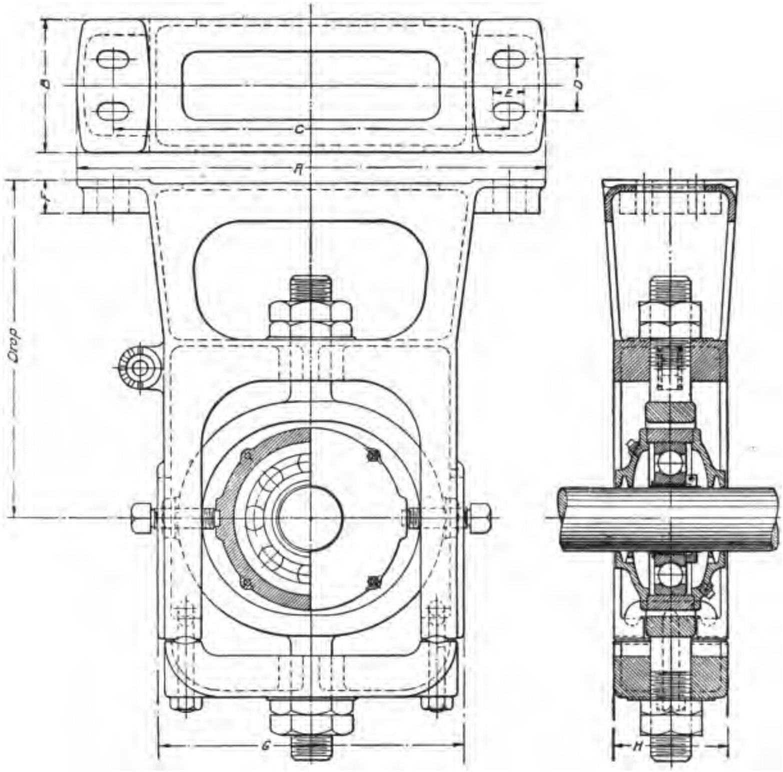


FIG. 332.—Ball Bearing Line Shaft Hanger.

A SWING REST

Another assembly drawing for a bench lathe appliance is shown in Fig. 334. This is a swing rest for the Ames bench lathe. There are three elevations here, two being front and rear elevations, while the central view is an end elevation. The elevations are in partial section to show certain features of construction more clearly than would otherwise be possible. Thus the spindle *A* and pivot shaft *B* are brought

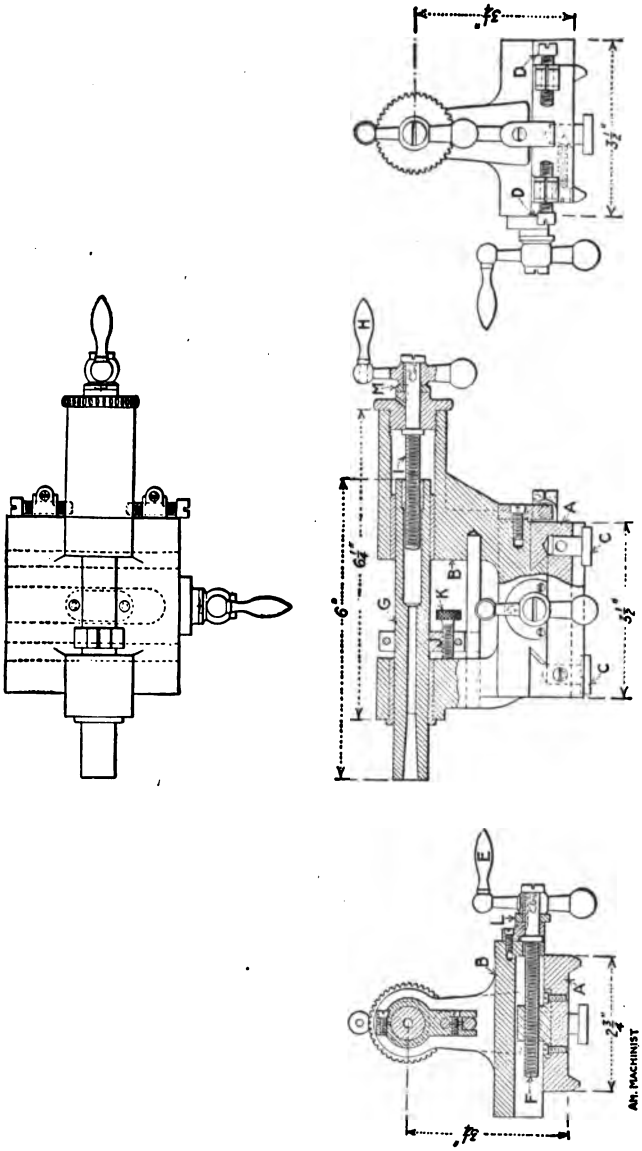
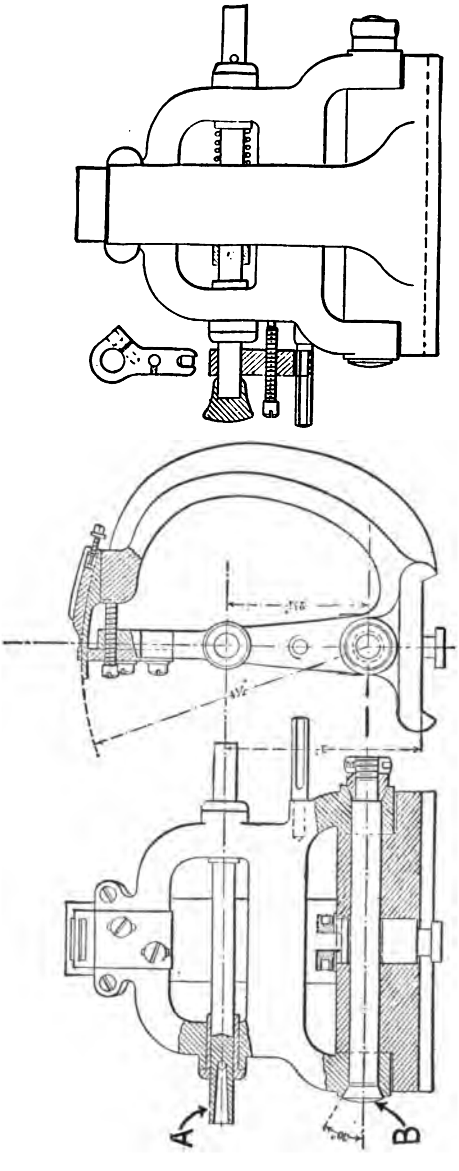


Fig. 333.—Cross-Slide Tailstock.



Rear Elevation.

End View.

Front Elevation.

FIG. 334.—Swing Rest.

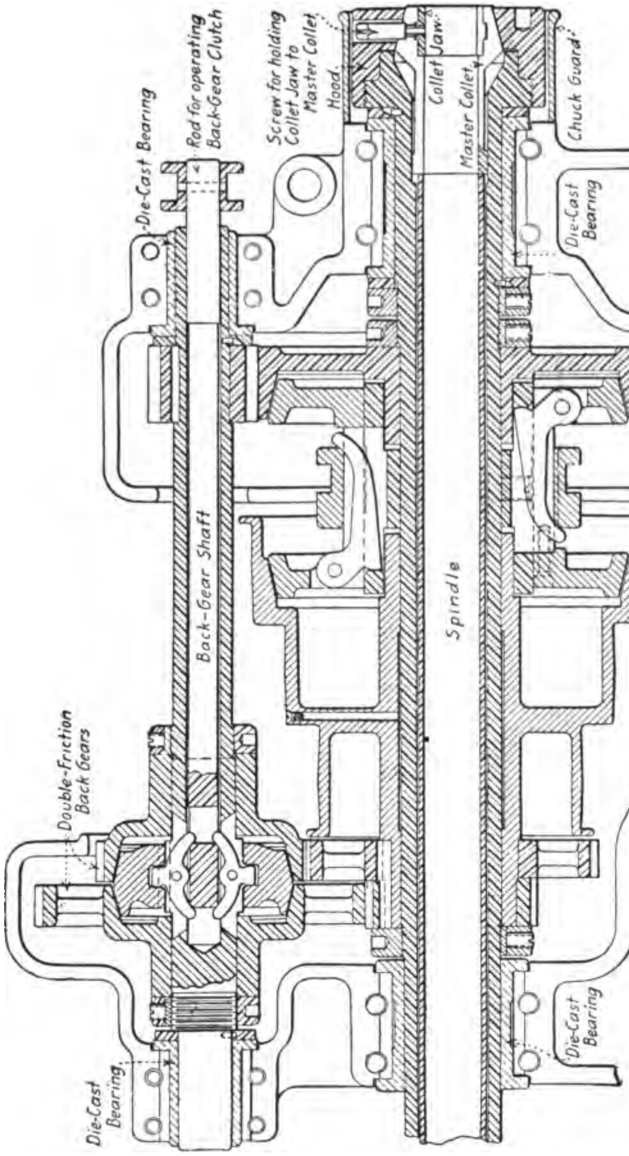
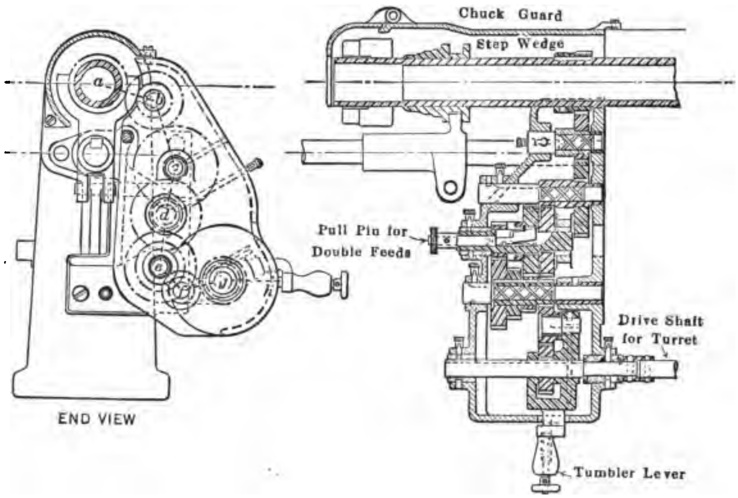


FIG. 335.—Horizontal Section of Headstock of Turret Lathe.

out clearly by sectioning and the stop device at the top is shown distinctly by the same means. The rear view has a part section at the left to show the stop for the traverse spindle movement.

TURRET LATHE HEAD AND FEED BOX

The turret lathe head stock in Fig. 335 is shown in plan view of the head itself though the mechanism is seen in section. That is the spindle, gears and back gear shaft are all shown



END VIEW

SECTION ON LINE *a-b-c-d-e-f-g-h*

Fig. 336 Fig. 337

Feed Mechanism with Operating Details.

as sectioned in the horizontal plane. The head is made in halves divided on the horizontal center line and the top of the head is removed in the view. The section cuts through the center of the mechanism and shows the interior of the hollow spindle, chuck, frictions, pulleys and gears and gives in the one view a clear conception of the entire spindle mechanism.

Another drawing of the feed box on the same machine is shown in Figs. 336 and 337. Examination of these views will reveal an important feature in showing a gear train in development. The vertical section, Fig. 337, extends downward much farther than the end view. This is because the gear train is shown in its development instead of on a straight vertical plane cutting through the central portion of the train. The latter method would result in certain of the gears being partly or entirely hidden by others in front. The only logical way in which such gear trains may be satisfactorily shown is to consider the entire train as developed or straightened out along one common center line and this is the method adopted in Fig. 337. Here the section is formed by laying out on the composite center line which is made up of the individual center distances of Fig. 336 as *a-b, b-c, c-d, d-e, e-f, f-g, g-h.* Thus we refer to section Fig. 337 as "Section along line *a-b-c-d-e-f-g-h.*" This shows the actual center distances between each set of gears and all gears, studs, shafts, etc., are represented in the clearest manner. But the actual *position* of these gears and other parts in the gear box and their angular location up and down and to right and left of any *fixed center line* must be taken from an end view such as Fig. 336, where the actual proportions of the gear box are seen and all center distances may be given correctly by horizontal and vertical dimensions.

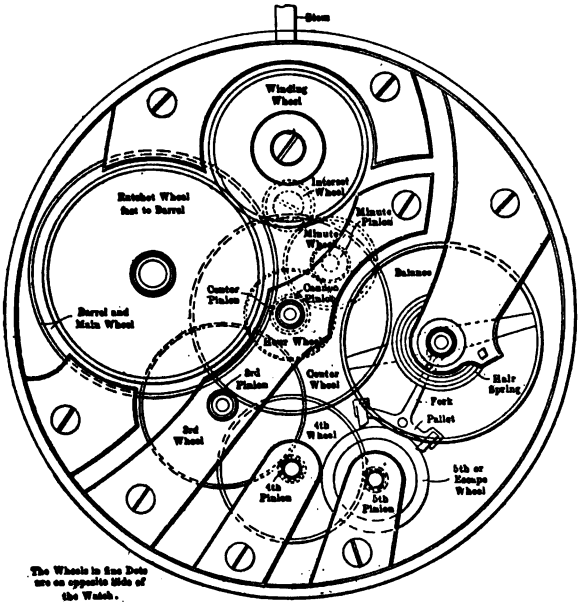


Fig. 338.—Watch Movement (Shown Enlarged).

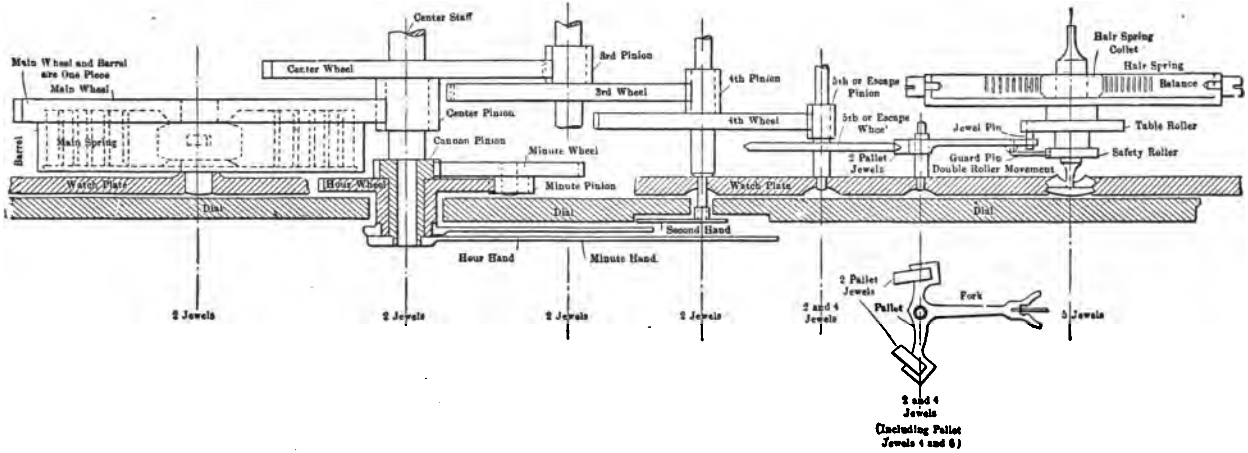


FIG. 339.—Development of Watch Movement.

DEVELOPMENT OF WATCH MOVEMENT

Perhaps the most striking example of a gear train development is to be found in a watch movement. In actual position such a movement is like Fig. 338, where the gear train centers are located along a nearly circular path. The development of such a movement is laid out as in Fig. 339 just as though all gear centers were in one straight line. This device enables every gear, staff, pivot and jewel to be shown distinctly where any other method of showing the movement in section or elevation would result in nothing but confusion of one part of the mechanism with another.

ANOTHER GEAR BOX

Fig. 340 illustrates a gear box equipped with roller bearings for the shafts. This gear box casting is made in two halves.

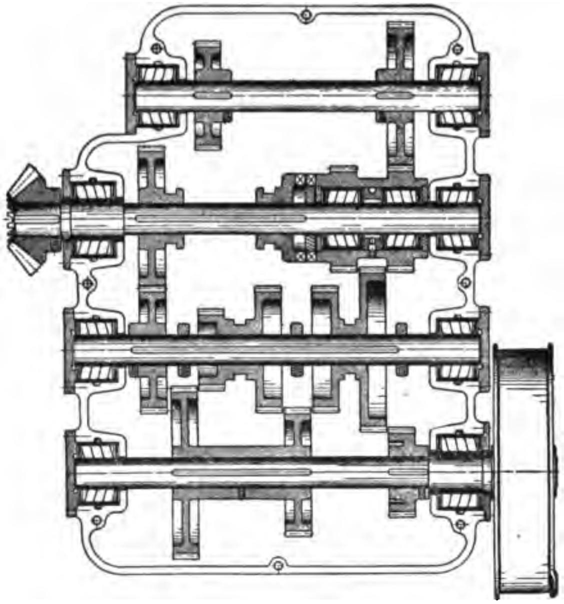


FIG. 340.—Gear Box Equipped with Roller Bearings.

That is, it is split along the center and the outer half or cover is removed in the assembly view herewith. As the view shows the edge of the box this portion is not cross hatched but is left in outline only. The gears, cover plates for the shaft ends, collars, etc., are sectioned and the shafts, pulley, and inside of the gears are line shaded, to give a cylindrical appearance. Line shading, as already pointed out, is not necessary on most drawings. Occasionally, however, it does add to the effectiveness of a drawing, particularly where only a single view is given. With the shafts the shading consists in drawing lines along the surface, which as they approach the edge of the piece come closer and closer together. They are usually best drawn by starting at the outer edge of the shaft and spacing them farther apart as they recede from the outer edge. With interior shading as with the gear sections, the heavy lines or closely spaced ones are at the edge of the section and become lighter and farther apart as they are drawn in toward the center. Usually it is best to shade for only about one-quarter of the diameter from each side whether on shafts or inside of cylindrical parts shown in section.

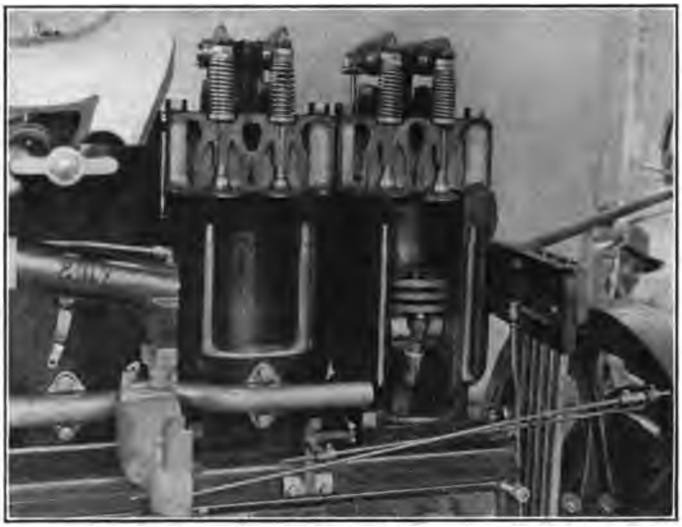


Fig. 341.—Cylinder and Valve Mechanism of Motor.

A VALVE MECHANISM

One more application of the use of assembly views is given in Figs. 341 and 342. The photograph in the first engraving

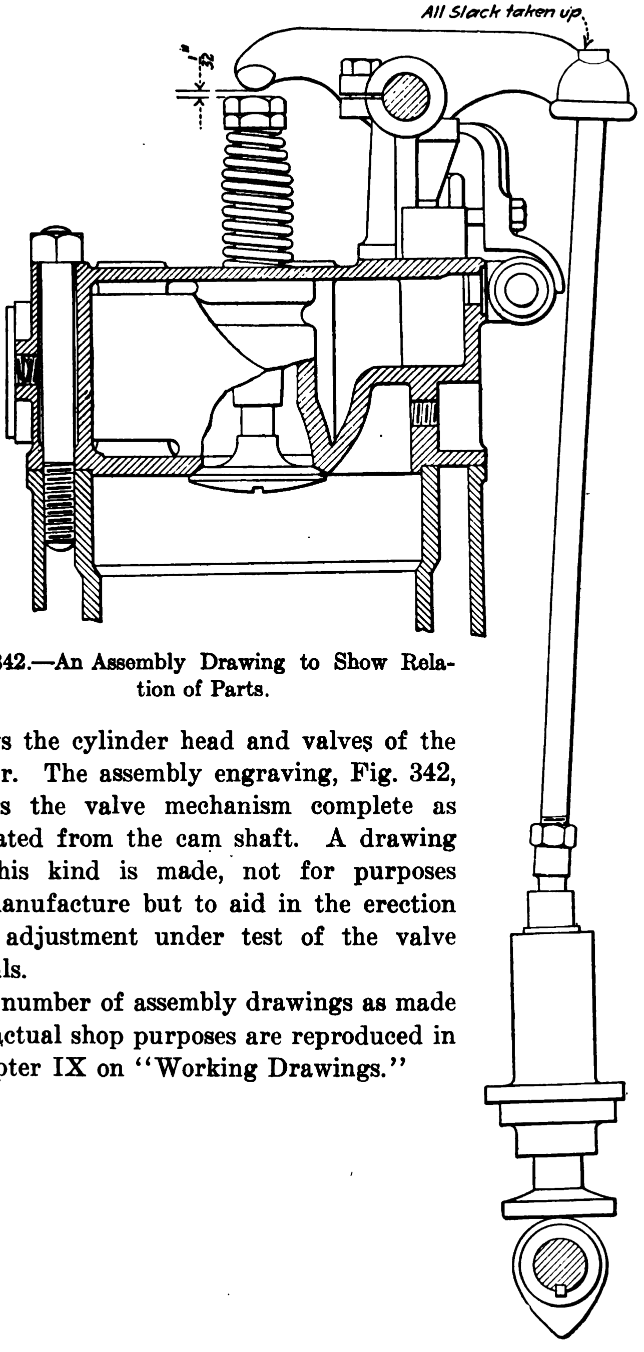


Fig. 342.—An Assembly Drawing to Show Relation of Parts.

shows the cylinder head and valves of the motor. The assembly engraving, Fig. 342, shows the valve mechanism complete as actuated from the cam shaft. A drawing of this kind is made, not for purposes of manufacture but to aid in the erection and adjustment under test of the valve details.

A number of assembly drawings as made for actual shop purposes are reproduced in Chapter IX on "Working Drawings."

CHAPTER IX

WORKING DRAWINGS

In Chapter III on "Practical Applications of the Principles of Projection," we have taken up a number of simple drawings of parts shown in two or three views and dimensioned as required for actual shop purposes. The present chapter and others that follow are devoted to working drawings of various classes from simple parts shown as details and to other work of more complex nature including certain assembly drawings all of which should be of interest and value to users of this book. These drawings are all reproduced from blue prints made in various important engineering plants and represent faithfully the practice of these firms in respect to working drawings. As with previous chapters, a liberal number of photographic views are included here to show the different parts as a whole and to add to the interest in the drawings which follow as well as to serve as an aid to a clear understanding of the drawings. It will be found very valuable practice to make drawings like those in the engravings, using any convenient scale.

Fig. 343 shows a bracket bearing for a pulley shaft, and a complete working drawing of this casting is reproduced in Fig. 344. It should be noted that provision is made on drawings for keeping a record of any changes that may ever be made in the original. Sometimes it may happen that a drawing is used for years without change, but this is a rare occurrence in any plant. Consequently it is of great importance to have a record on the tracing and blueprints of actual changes, no matter how trivial, and the date of change should also be noted. The form at the bottom of a drawing should have columns for dates, and if this is a new drawing taking the place of an earlier one the drawing which it supersedes is designated at the bottom of the form at the left. If in time it is itself superseded by another drawing the number and date are given in another lower space at the middle of the form. Slight changes do not necessitate the making of a new drawing and such changes may be recorded in a column headed "Note No."

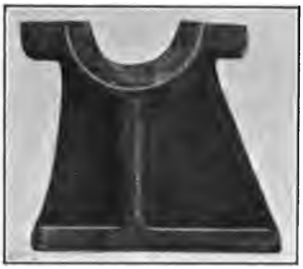


Fig. 343.—Bearing for Shaft. See Drawing Fig. 344.

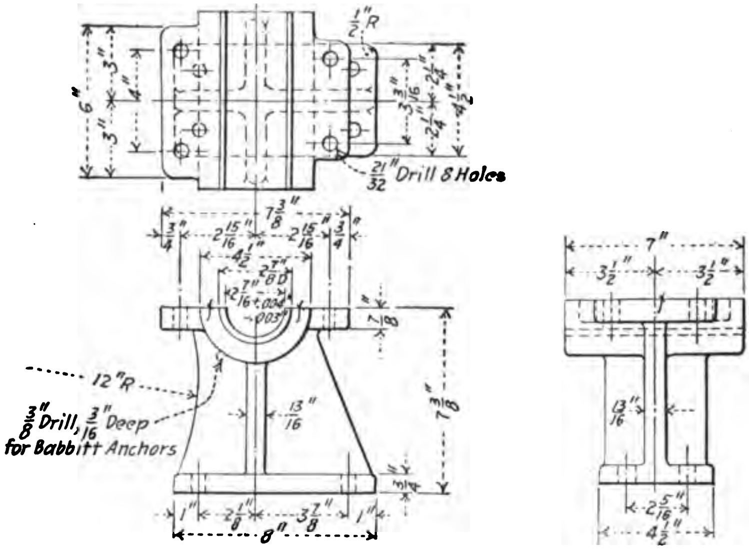


Fig. 344.—Drawing of Shaft Bearing.

Fig. 345 is another shaft box, the cap for which is not included in the view. The working drawing of this part is shown in Fig. 346. Note the neat arrow heads on the ends of the dimension lines and the even character of all classes of lines.

Practice with the pen until slender even arrows are made without difficulty. A stubbed arrow point is due to carelessness or inexperience. The skilled draftsman is as neat with his arrows and finish marks (*f*) as with his other work.

The lever in Fig. 347 has a pivot hole and a stud hole, and is ribbed for stiffness. The working drawing for this lever is shown in Fig. 348.

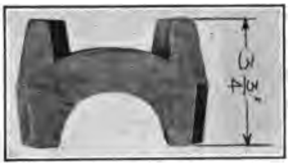


FIG. 345.—Shaft Box Cap. See Drawing Fig. 346.

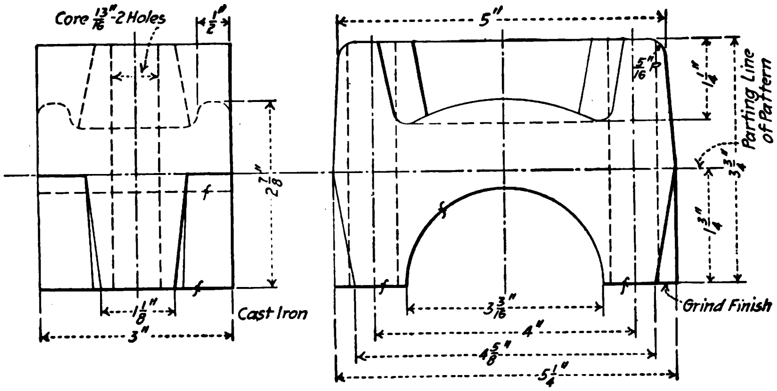


FIG. 346.—Drawing of Shaft Box Cap.

The cap in Fig. 349 is for a crank shaft box which is not seen in this photograph. The working drawing, Fig. 350, includes the box as well as this cap.

Draw an additional view, the plan showing the top of the cap. Draw this plan over the top of the front elevation.

The truck wheels in Fig. 351 are shown in section in Fig. 352. The hole or bore through the casting is chambered at the middle of the length and the bearing surface in the bore is marked with limit dimensions, as $\frac{2.688.}{2.687}$ This means that the hole may be from 2.687 to 2.688 in diameter and still be within the necessary limit which is here 0.001 inch. This matter of dimension limits is a most important one in modern manufacture and the draftsman in the progressive plant must become familiar with the systems of limits requisite for interchangeable manufacture. The subject is treated at length in another chapter.

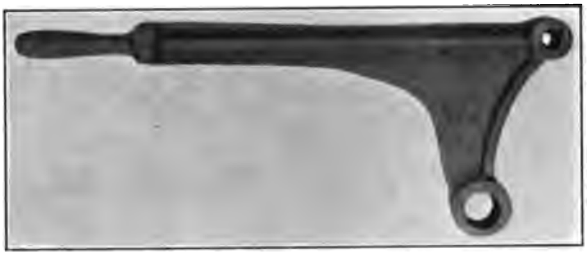


Fig. 347.—Hand Lever. See Drawing Fig. 348.

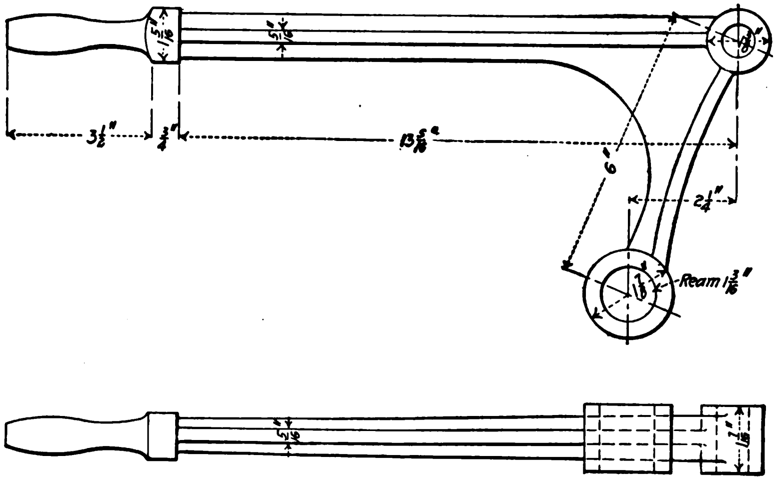


Fig. 348.—Drawing of Hand Lever.

In addition to the two views of Fig. 352 draw a third

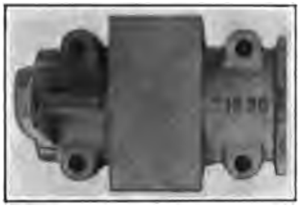


FIG. 349.—Cap for Bearing Box. See Drawing Fig. 350.

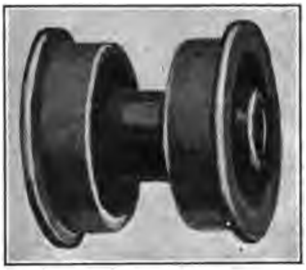


FIG. 351.—Truck Wheels. See Drawing Fig. 352.

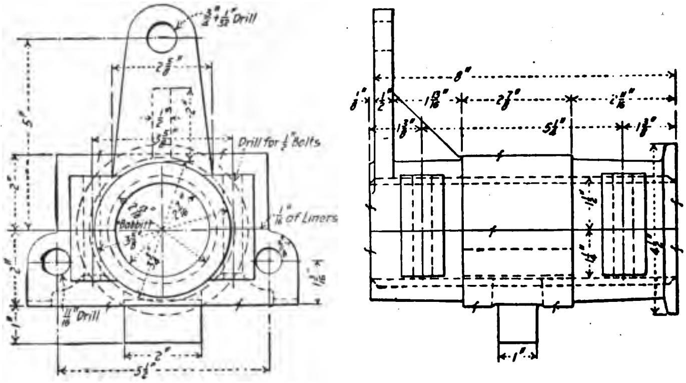
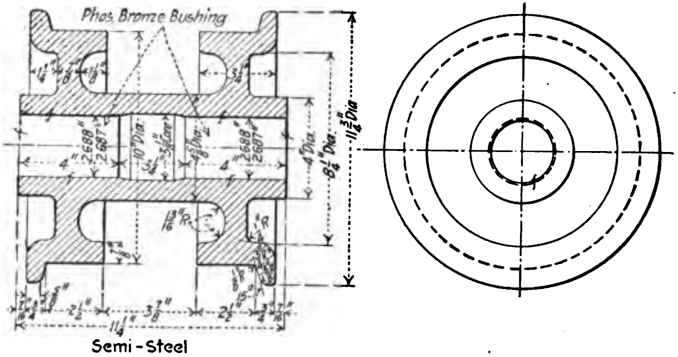
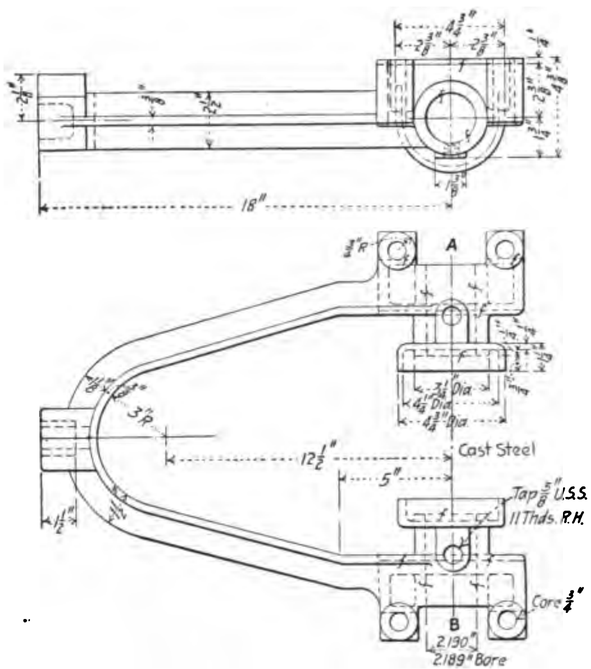


FIG. 350.—Drawing of Cap for Bearing Box.



Semi-Steel

FIG. 352.—Drawing of Truck Wheels.



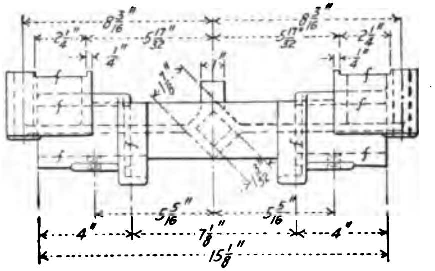


FIG. 354.—Drawing of Forked Bracket.

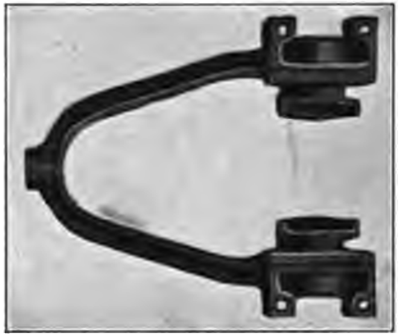


FIG. 353.—Forked Bracket. See Drawing Fig. 354.

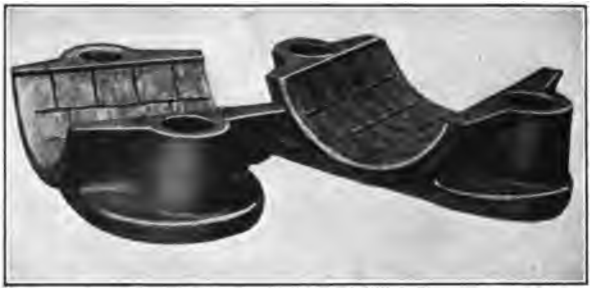


FIG. 355.—Connecting Rod Brasses. Shown in Rod End, Fig. 356.

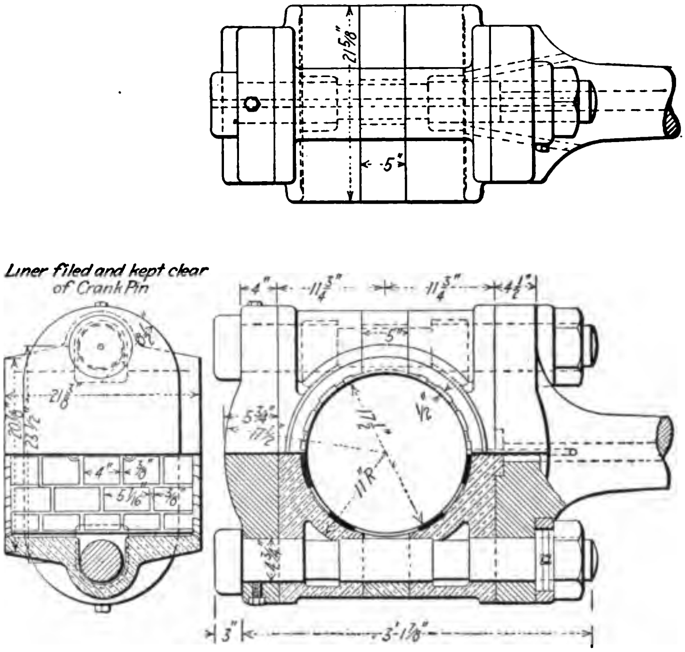


FIG. 356.—Drawing of Connecting Rod for Marine Engine Showing Brasses in Place.

view showing an elevation of the wheels with the outside of the flanges, body, etc., seen as an external view.

Fig. 353 illustrates a forked bracket which is shown in the drawing, Fig. 354.

Draw a cross-section along line *A-B* showing the bore through both forks at the bracket.

TWO TYPES OF CONNECTING RODS

The connecting rod brasses in Fig. 355 are for the main engine of a big steamship, the rod end for these brasses being shown by the drawing, Fig. 356.

Draw a detail of one of these brasses using the dimensions of Fig. 356 and also make a detail drawing of the through bolt for one side of the brass and rod. Certain dimensions are purposely omitted here. Find these dimensions either by scaling the drawing of the rod or by computing from the other dimensions.

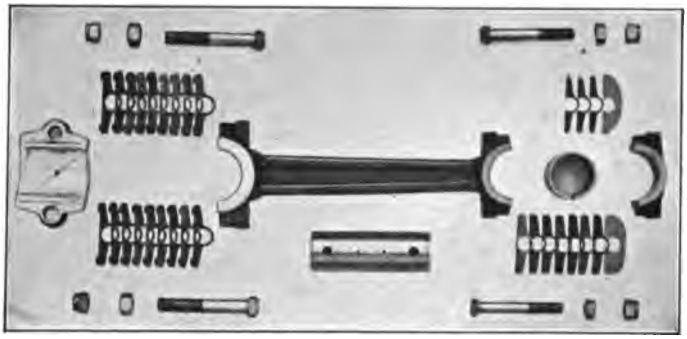


Fig. 357.—Details of Connecting Rod Shown by Drawing Fig. 358.

A photographic group of the details of a connecting rod for a motor is illustrated in Fig. 357. The rod and its caps are shown in the working drawing, Fig. 358.

Note the instructions for drilling and reaming to definite sizes. Also note the limits given for certain dimensions.

The cylinder head photograph in Fig. 359 shows also the valve, guide, spring, etc. The drawing of this head is reproduced in Fig. 360.

This drawing is a very good one for practice for the reader. It shows the head walls and water chambers, the stud holes, the valve seats and guide seats, the connections, etc.

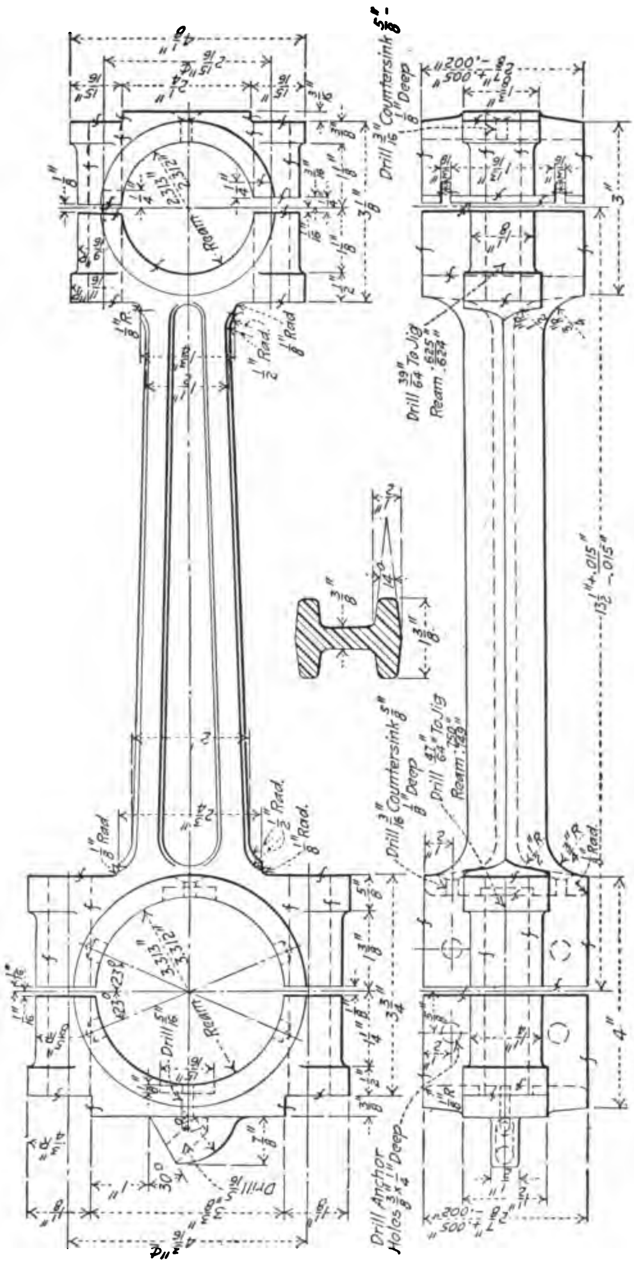

Drill 3/16" Countersink 5/8" 1/8" Deep
Ream
Drill 39/64" To Jig Ream .625" .624"
Drill 3/16" Countersink 5/8" 1/8" Deep
Drill 47/64" To Jig Ream .750" .749"
Drill 5/16"
Drill Anchor Holes 3/8" x 1/4" Deep
13 1/2" +.015" -.015"
3"
4"
1/2" Rad.
1/8" Rad.

FIG. 358.—Drawing of Connecting Rod.

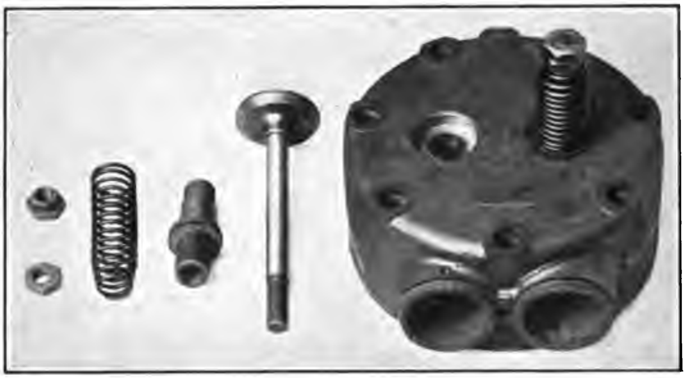


FIG. 359.—Cylinder Head for Motor. See Drawing Fig. 360.

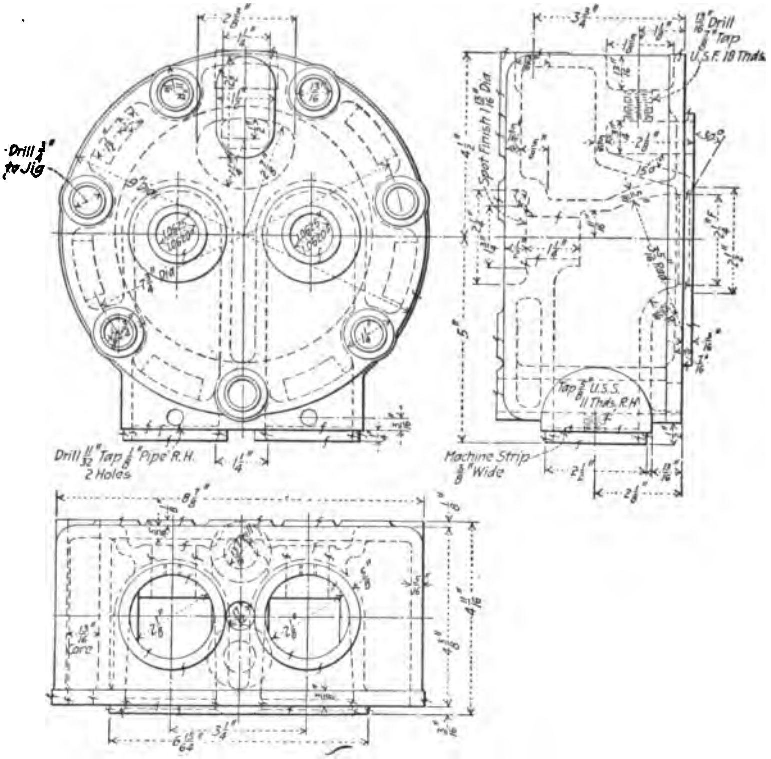

Drill 3/4" to Jig
Drill 11/32" Tap 1/8" Pipe R.H. 2 Holes
Machine Strip 3/8" Wide
Spot Finish 1 13/16" Dia.
13/16" Drill 7/8" Tap U.S.F. 18 Thds.
Tap 3/4" U.S.S. 11 Thds. R.H.
Core
7/8" Dia
8 7/8"
3 3/4"

FIG. 360.—Drawing of Cylinder Head for Motor.

SOME STEAM FITTINGS

Fig. 361 is a blow off cock body and fittings, the drawing for which is reproduced in Fig. 362.

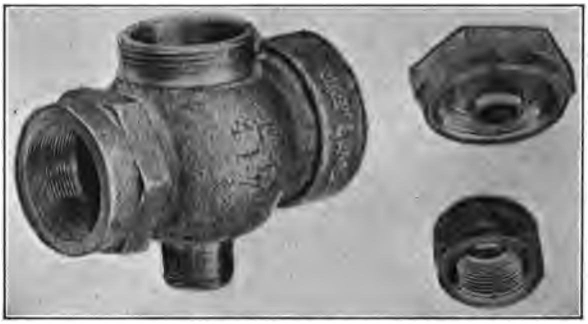
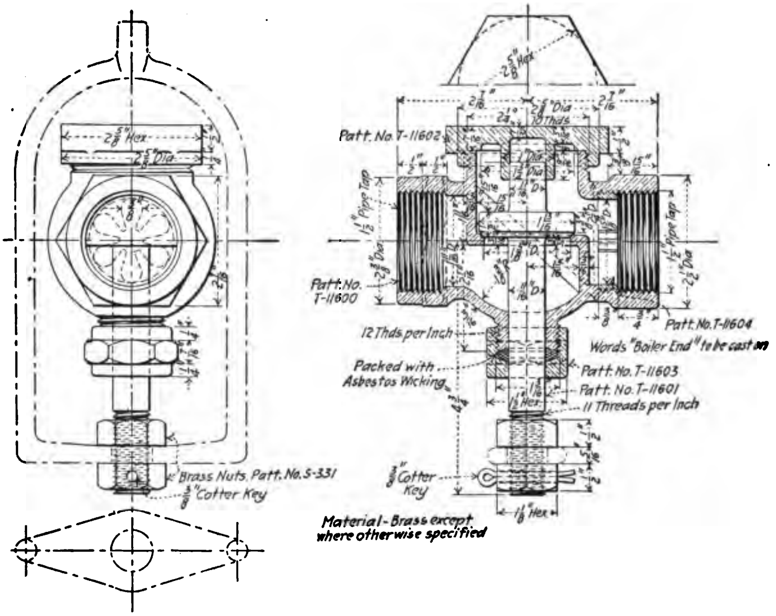


FIG. 361.—Blow-off Valve Parts. See Drawing Fig. 362.



$2\frac{5}{8}''$ Hex
$2\frac{5}{8}''$ Dia
Brass Nuts, Patt. No. S-331
$\frac{3}{8}''$ Cotter Key
Patt. No. T-11602
Patt. No. T-11600
$1\frac{1}{2}''$ Pipe Tap
$2\frac{3}{8}''$ Dia
$2\frac{5}{8}''$ Dia 10 Thds
12 Thds per Inch
Packed with Asbestos Wicking
Patt. No. T-11604
Words "Boiler End" to be cast on
Patt. No. T-11603
Patt. No. T-11601
11 Threads per Inch
$1\frac{1}{2}''$ Hex
$\frac{3}{8}''$ Cotter Key
$1\frac{1}{8}''$ Hex
Material - Brass except where otherwise specified

FIG. 362.—Drawing of Blow-off Valve.

Note that the pattern numbers are here given on each detail. Also note the method of indicating the form of the operating lever bracket used with this device. The bracket is merely outlined here with dot and dash lines, and a note is added referring to the number of the drawing which shows lever and bracket. This separation of the details of the bracket and lever prevents confusion on the assembly drawing here illustrated.

Make detail drawings of the valve stem, the cap and the gland nut, showing each in plan and section.

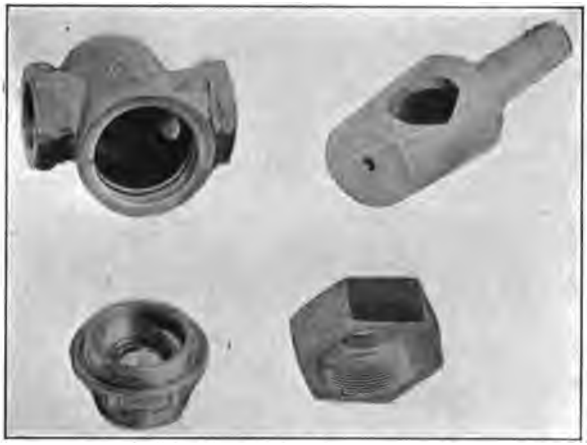


FIG. 363.—Oil Feed Cock. See Drawing Fig. 364.

Fig. 363 is a group photograph of the details of a 1½ inch oil feed cock. The assembly drawing of this appliance is given in Fig. 364.

Study this drawing and note the clearness with which all details are brought out by the sections in the assembly views. Make drawings of these details showing each in plan and section.

Fig. 365 is a drawing in assembly of a cylinder cock. Draw the valve in detail.

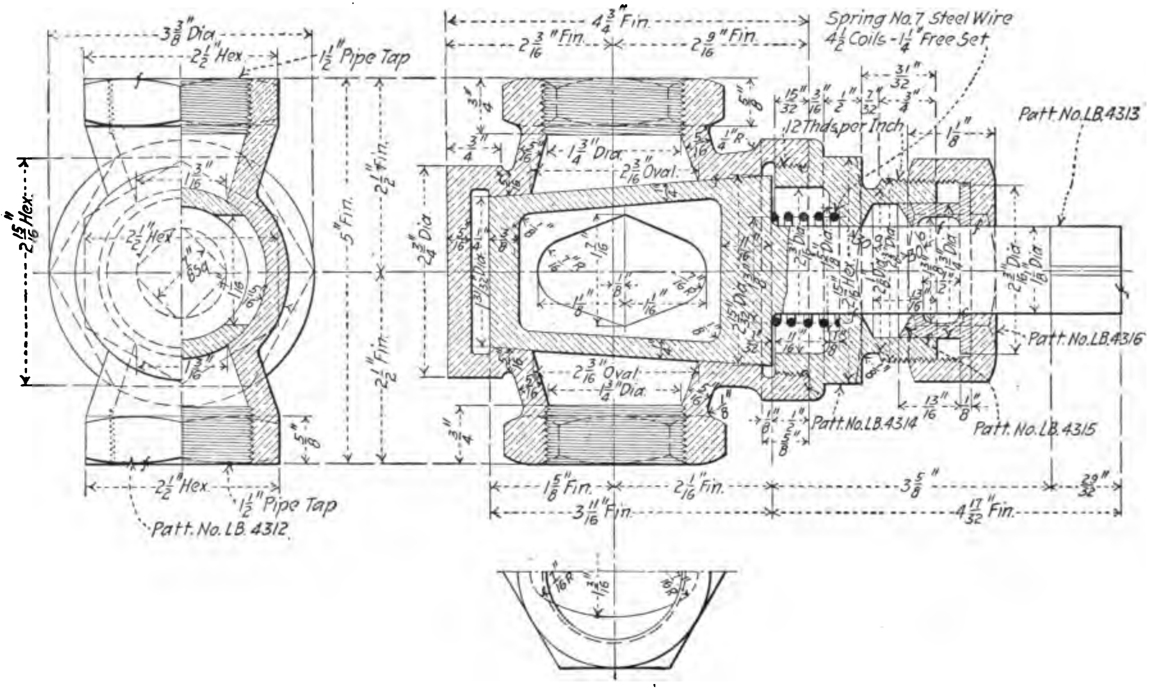


FIG. 364.—Drawing of Oil Feed Cock.

PISTON AND CROSS HEAD

The half tone Fig. 366 represents a locomotive piston and rod and the line engraving Fig. 367 shows the working drawing.

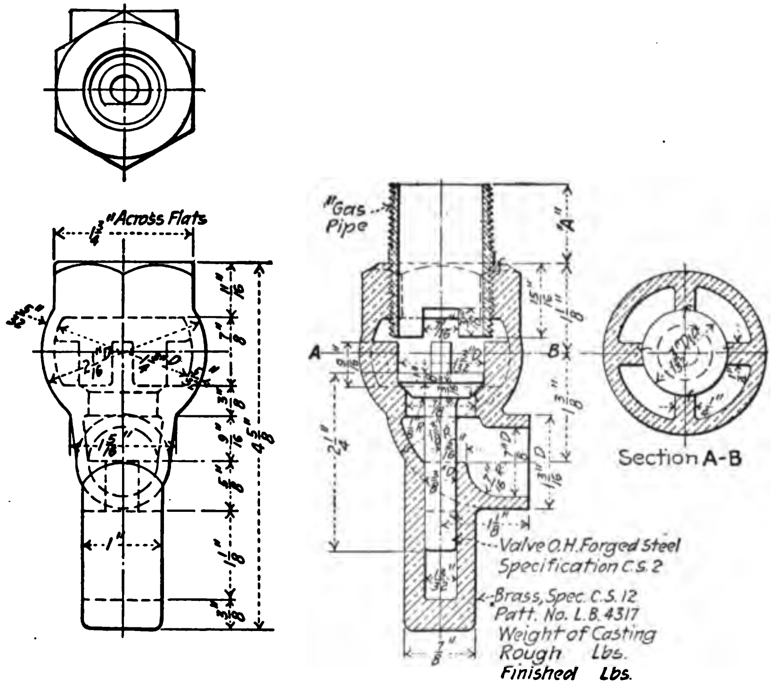


Fig. 365.—Drawing of Cylinder Cocks.

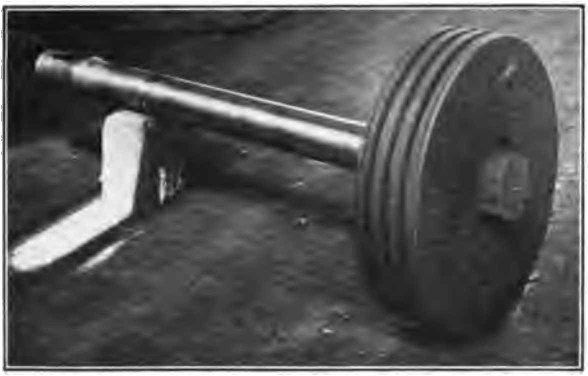
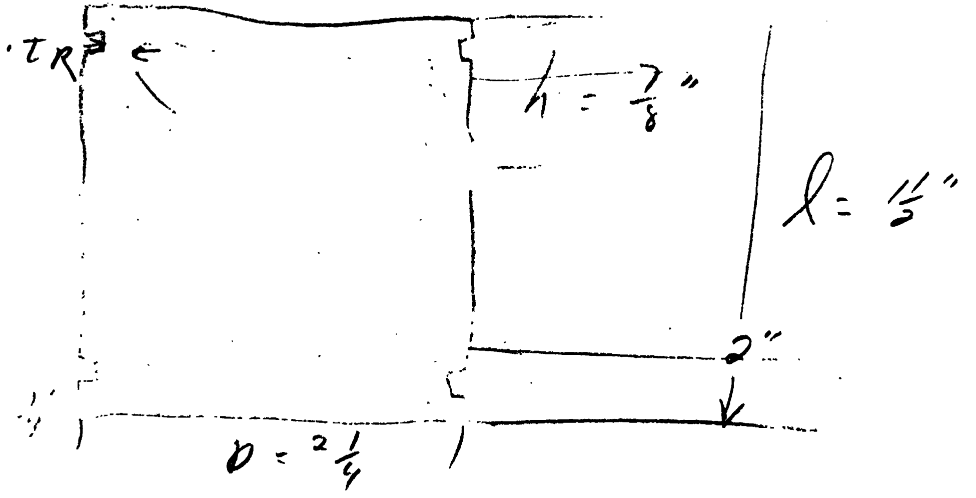


Fig. 366.—Locomotive Piston. See Drawing Fig. 367.

Max .1885

Min .1875



.032D + .06"

.032275

.064
.06
.004

③

1.8
16) .30.
16
140
8
(12)

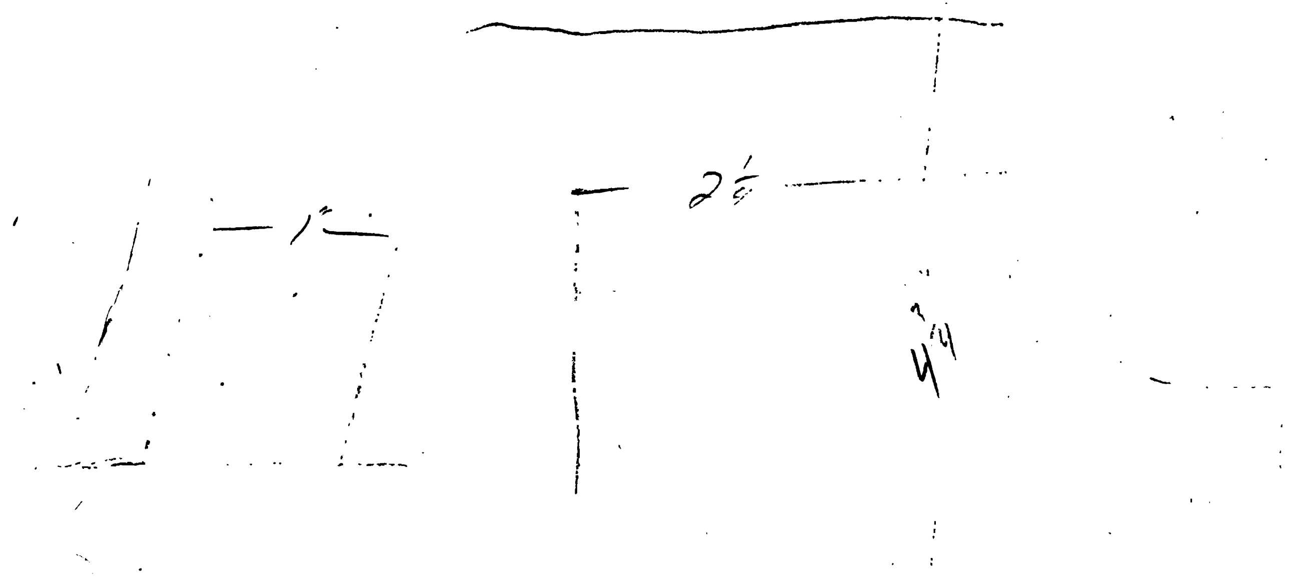
$4\frac{1}{2}$" bolts

$\frac{3}{8}$" thick.

$.1 = \frac{1.6}{.6}$

$.1 =$ [illegible]

$x = 6.4$



Couplings — SQ

Nominal Ring width $\frac{1}{8}$"

Max .1240
Min .1235

Groove Width

Max .1265
Min .1255

Oil rings will be $\frac{3}{16}$" x $\frac{1}{8}$" thick

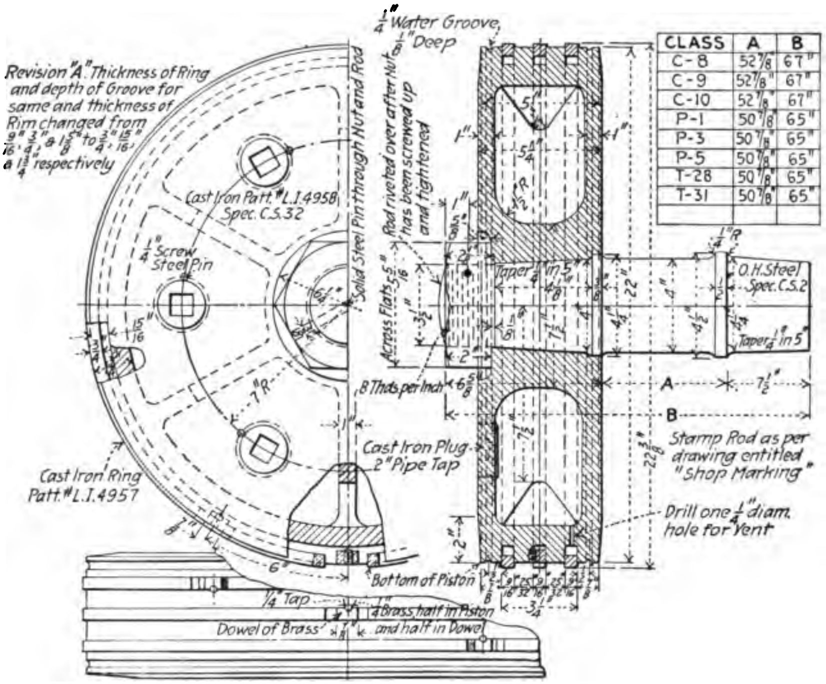
Max ring width = .1865
Min .1855

Groove

1.16

$$\frac{\frac{3}{16} = X}{\frac{1.6}{16} = .1}$$

$$\frac{\frac{.3}{16}}{\frac{1.6}{16}}$$


Revision "A". Thickness of Ring and depth of Groove for same and thickness of Rim changed from 9/16", 3/4", & 1 5/8" to 3/4", 15/16", & 1 3/4" respectively
1/4" Water Groove, 1/8" Deep
Cast Iron Patt. # L.I.4958 Spec. C.S.32
1/4" Screw Steel Pin
Solid Steel Pin through Nut and Rod
Rod riveted over after Nut has been screwed up and tightened
Across Flats 5 5/16"
8 Thds. per Inch
Cast Iron Plug 2" Pipe Tap
Cast Iron Ring Patt. # L.I.4957
Bottom of Piston
1/4" Tap
1/4" Brass half in Piston and half in Dowel
Dowel of Brass
O.H. Steel Spec. C.S.2
Taper 1/4" in 5"
Stamp Rod as per drawing entitled "Shop Marking"
Drill one 1/4" diam. hole for Vent
A
B

CLASS	A	B
C-8	52 7/8	67"
C-9	52 7/8"	67"
C-10	52 7/8"	67"
P-1	50 7/8"	65"
P-3	50 7/8"	65"
P-5	50 7/8"	65"
T-28	50 7/8"	65"
T-31	50 7/8"	65"

FIG. 367.—Drawing of Locomotive Piston.

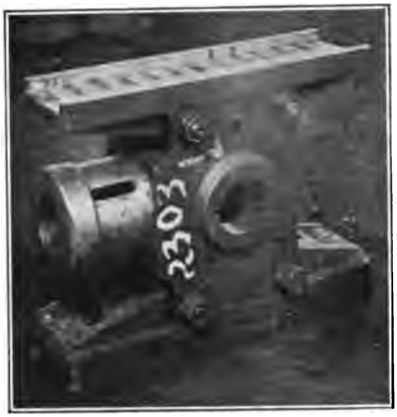


FIG. 368.—Locomotive Cross Head. See Drawing Fig. 369.

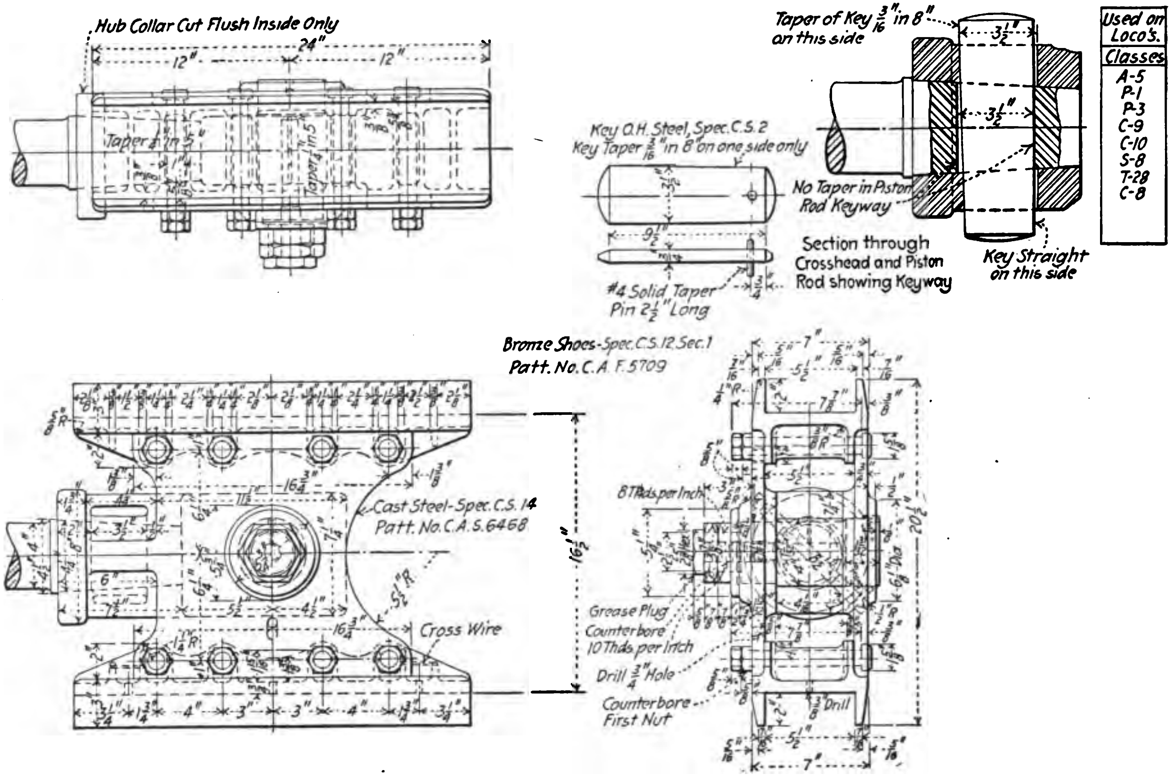

Hub Collar Cut Flush Inside Only
24"
12"
12"
Taper $\frac{1}{4}$" in 5"
Taper $\frac{1}{4}$" in 5
Key Q.H. Steel, Spec. C.S. 2
Key Taper $\frac{3}{16}$" in 8" on one side only
$9\frac{1}{2}$"
#4 Solid Taper Pin $2\frac{1}{2}$" Long
Taper of Key $\frac{3}{16}$" in 8" on this side
$3\frac{1}{2}$"
No Taper in Piston Rod Keyway
Key Straight on this side
Section through Crosshead and Piston Rod showing Keyway
Used on Loco's.
Classes
A-5
P-1
P-3
C-9
C-10
S-8
T-28
C-8
Bronze Shoes-Spec. C.S. 12 Sec. 1
Patt. No. C.A. F. 5709
Cast Steel-Spec. C.S. 14
Patt. No. C.A.S. 6468
$16\frac{1}{2}$"
$16\frac{3}{4}$"
$5\frac{1}{2}$" R
Cross Wire
8 Thds per Inch
Grease Plug
Counterbore
10 Thds per Inch
Drill $\frac{3}{4}$" Hole
Counterbore First Nut
$\frac{3}{8}$" Drill
$20\frac{1}{2}$"
7"
$5\frac{1}{2}$"
$7\frac{7}{8}$"

FIG. 369.—Drawing of Locomotive Cross Head.

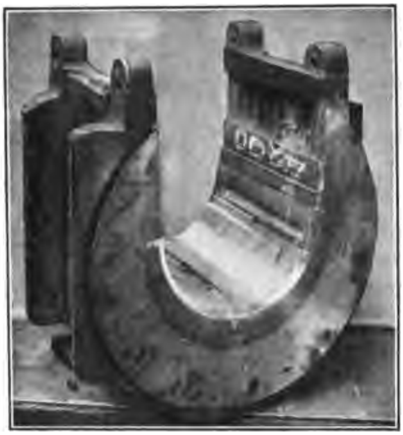


FIG. 370.—Driving Box for Locomotive. See Drawing Fig. 372.

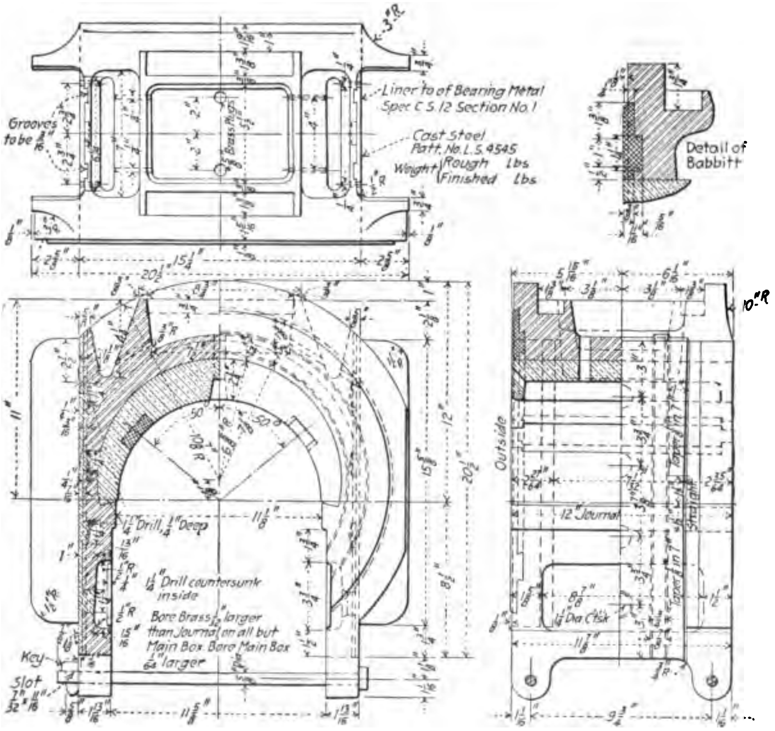


FIG. 371.—Drawing of Driving Box.

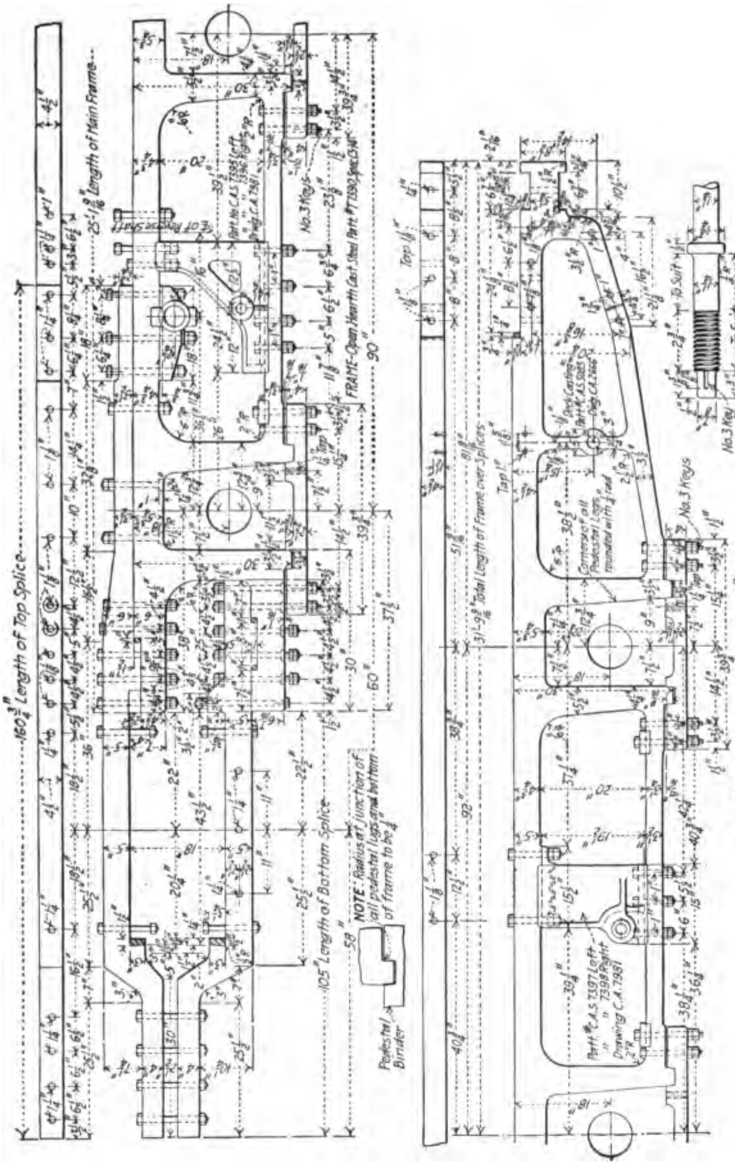

160¾" Length of Top Splice
25'-1 9/16" Length of Main Frame
105" Length of Bottom Splice
NOTE: Radius at junction of all pedestal lugs and bottom of frame to be ¾"
Pedestal Binder
FRAME-Open Hearth Cast Steel Part #7390 Spec. 374
No.3 Keys
31'-9⅜" Total Length of Frame over Splices
Corners of all Pedestal Legs rounded with ½" rad.
NOTE: Holes in pedestal binders to be 1/16" larger diameter than pedestal binder bolts
Detail of Pedestal Bolts
No.3 Key

FIG. 372.—Showing Method of Arranging Drawing of Locomotive Side Frame.

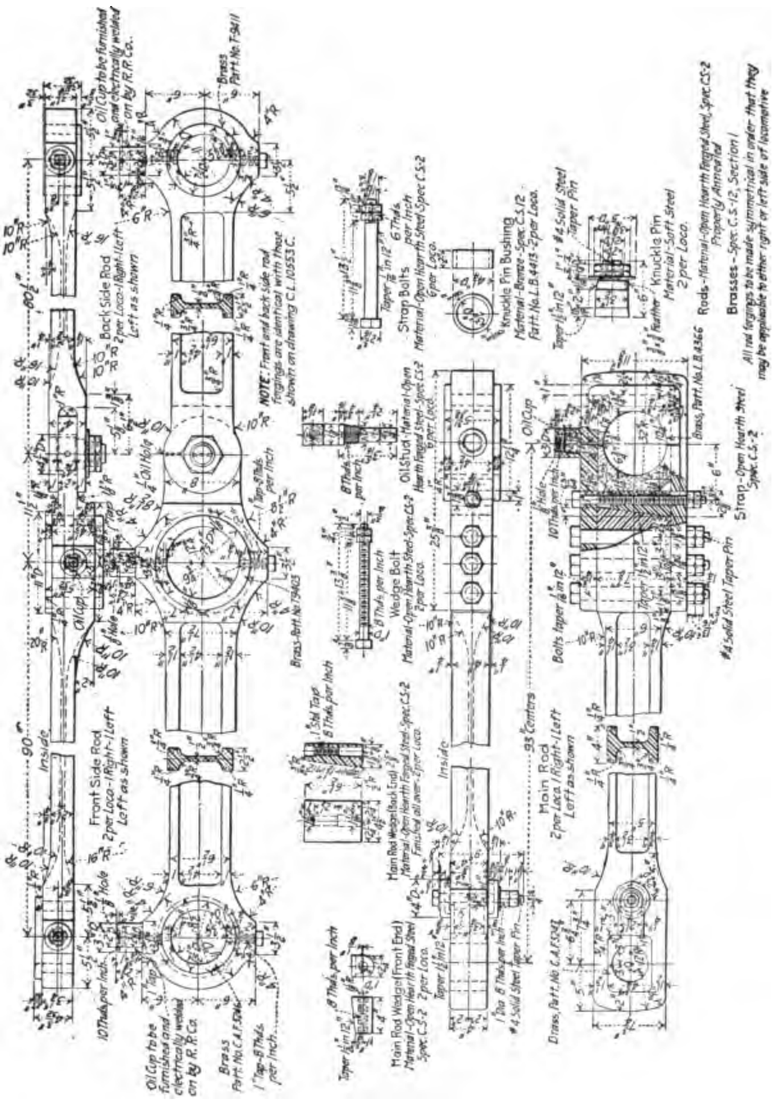

Front Side Rod
2 per Loco.-1 Right-1 Left
Left as shown
Back Side Rod
2 per Loco.-1 Right-1 Left
Left as shown
Main Rod
2 per Loco.-1 Right-1 Left
Left as shown
Inside
Oil Cup
Oil Hole
Strap Bolts
Wedge Bolt
Oil Stud
Knuckle Pin Bushing
Knuckle Pin
Main Rod Wedge (Front End)
Main Rod Wedge (Back End)
93" Centers
NOTE: Front and back side rod forgings are identical with those shown on drawing C.L.10553 C.
Rods-Material-Open Hearth Forged Steel, Spec. C.S.-2 Properly Annealed
Brasses-Spec. C.S.-12, Section 1
All rod forgings to be made symmetrical in order that they may be applicable to either right or left side of locomotive

FIG. 373.—Showing Arrangement of Views of Locomotive Side Rods.

Note the manner in which the face of the piston is broken out to show portions of the ring and groove as well as the thickness of the metal under the bottom of the groove. Note the taper fit of the rod end in the piston bore and the method of designating the taper, thus, "Taper 1/4" in 5"." The table in the upper right hand corner gives the length dimensions *A* and *B* for various classes of piston rods. Select some particular class of rod and draw a detail showing *A* and *B* as called for in the table. For the cross-head end of the piston rod refer to Figs. 368 and 369, which are respectively photograph and working drawing of a cross-head. It may be noted that the photograph actually shows a cross-head with four shoe bolts only, but the general proportions conform to those in the drawing.

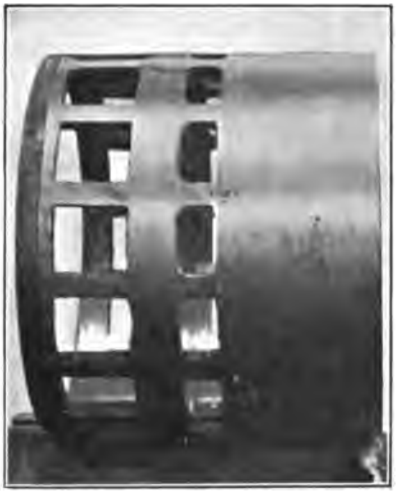
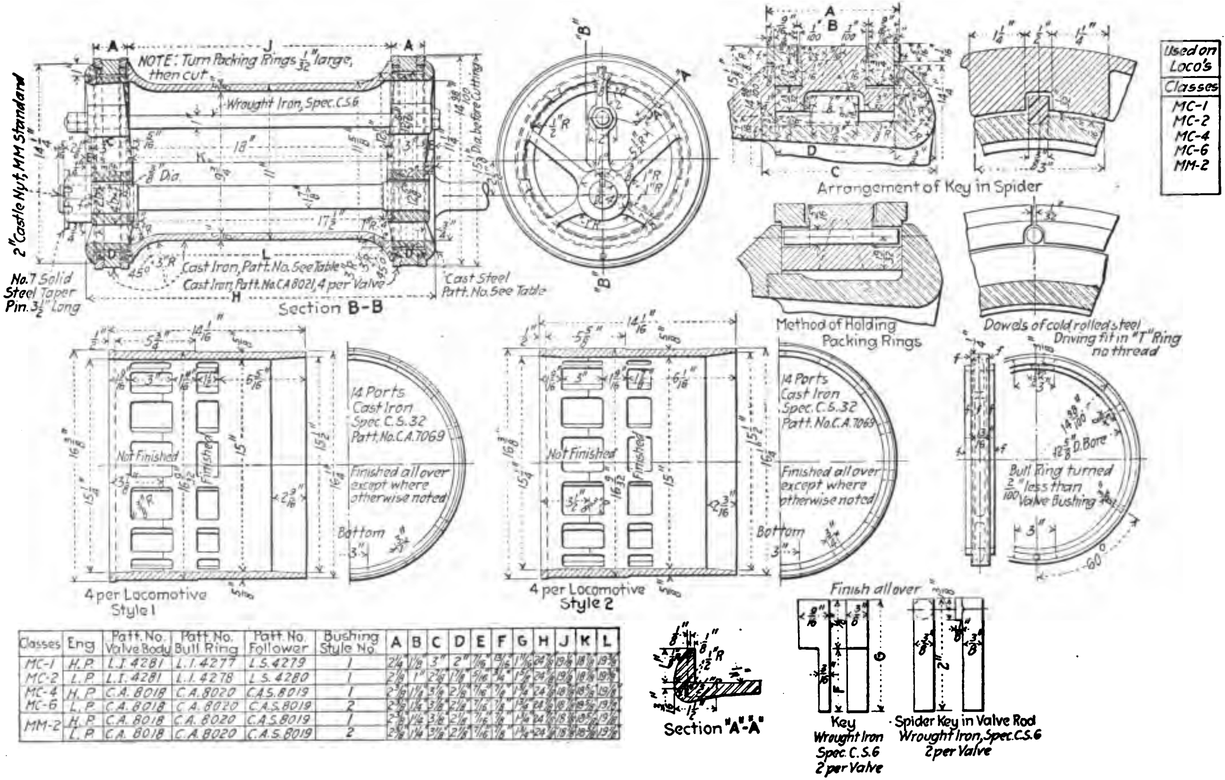


Fig. 374.—Locomotive Steam Chest Valve Bushing. See Drawing Fig. 375.

The rod end for the cross-head fit is detailed in the upper right-hand corner of Fig. 369. The key is also shown here.

DRIVING BOX AND SIDE FRAME

An 11" by 12" driving box is illustrated by Fig. 370. The working drawing is shown by Fig. 371. Note the half sections in the different views to show the brasses, lining metal, etc.,


NOTE: Turn Packing Rings 1/32" large, then cut.
Wrought Iron, Spec. C.S.6
2" Castle Nut, M.M. Standard
No. 7 Solid Steel Taper Pin 3½" Long
Cast Iron, Patt. No. See Table
Cast Iron, Patt. No. C.A.8021, 4 per Valve
Cast Steel Patt. No. See Table
Dia. before Cutting
Section B-B
"B"
Arrangement of Key in Spider
Method of Holding Packing Rings
Dowels of cold rolled steel Driving fit in "T" Ring no thread
Bull Ring turned 2/100" less than Valve Bushing
D. Bore
14 Ports Cast Iron Spec. C.S.32 Patt. No. C.A.7069
Finished all over except where otherwise noted
Not Finished
Finished
Bottom
4 per Locomotive Style 1
4 per Locomotive Style 2
Section "A"-"A"
Finish all over
Key Wrought Iron Spec. C.S.6 2 per Valve
Spider Key in Valve Rod Wrought Iron, Spec. C.S.6 2 per Valve
Used on Loco's
Classes
MC-1
MC-2
MC-4
MC-6
MM-2

Classes	Eng	Patt. No. Valve Body	Patt. No. Bull Ring	Patt. No. Follower	Bushing Style No.	A	B	C	D	E	F	G	H	J	K	L
MC-1	H.P.	L.I.4281	L.I.4277	L.S.4279	1	2¼	1⅛	3"	2"	7/16"	13/16"	1 11/16	24 [illegible]	19 [illegible]	18 [illegible]	19 [illegible]
MC-2	L.P.	L.I.4281	L.I.4278	L.S.4280	1	2⅛	1"	2⅞	1⅞	5/16"	¾"	1⅝	24 [illegible]	19½	18 [illegible]	19 [illegible]
MC-4	H.P.	C.A.8018	C.A.8020	C.A.S.8019	1	2⅜	1¼	3⅛	2⅛"	7/16"	⅞"	1¾"	24 [illegible]	18 [illegible]	18⅝	19⅛
MC-6	L.P.	C.A.8018	C.A.8020	C.A.S.8019	2	2⅜	1¼	3⅛"	2⅛	7/16	⅞"	1¾"	24 [illegible]	18 [illegible]	18⅝	19⅛
MM-2	H.P.	C.A.8018	C.A.8020	C.A.S.8019	1	2⅜	1¼	3⅛	2⅛	7/16"	⅞"	1¾"	24 [illegible]	18 [illegible]	18⅝	19⅛
	L.P.	C.A.8018	C.A.8020	C.A.S.8019	2	2⅜	1¼	3⅛"	2⅛	7/16	⅞"	1¾	24 [illegible]	18 [illegible]	18⅝	19⅛

FIG. 375.—Showing Details on Drawing of Piston Valve and Bushings.

clearly. Also examine into the method of anchoring the liner metal and the lateral bearing of babbitt.

Fig. 372 is a drawing of a locomotive frame and illustrates a case where a very long part must be drawn by showing in two or more lengths across the paper. Thus the present frame is over all nearly 32 feet in length and to show this in one continuous length on the paper would mean too small a scale for convenience.

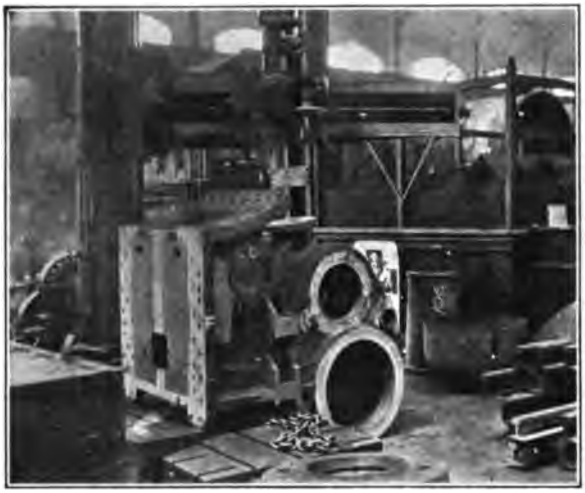


FIG. 376.—Locomotive Cylinder. See Drawing Fig. 377.

Draw a portion of this frame and practice placing the bolts accurately and drawing their heads and nuts neatly and to uniform size.

CONNECTING RODS, CYLINDERS, STEAM CHEST VALVES

A very interesting group of parts for practice in drawing will be found in Fig. 373 which gives assembly and detail drawings of main rods and side rods for a locomotive.

Fig. 374 is a valve bushing for a steam chest and the drawing for this and also for the valve is shown in Fig. 375.

Fig. 376 is a photograph of a locomotive cylinder and Fig. 377 a working drawing of this cylinder. The cylinder is a complicated piece of work with its numerous ports and cored chambers and considerable skill with the drawing tools will be necessary before a satisfactory drawing can be made along the lines of Fig. 377.

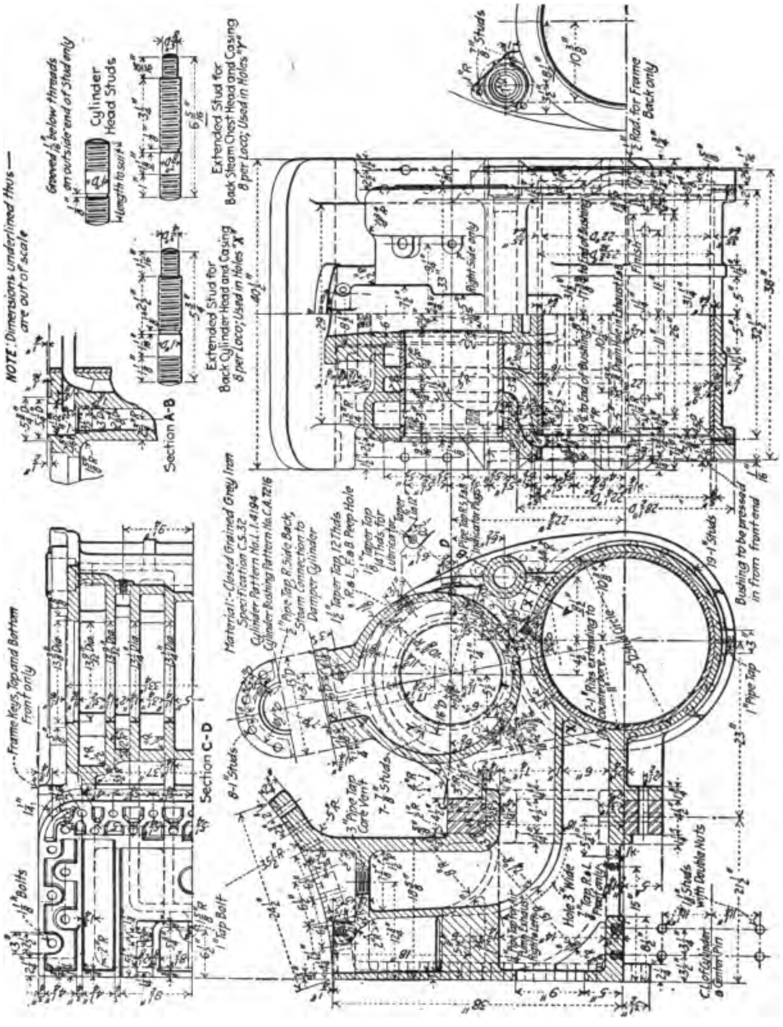
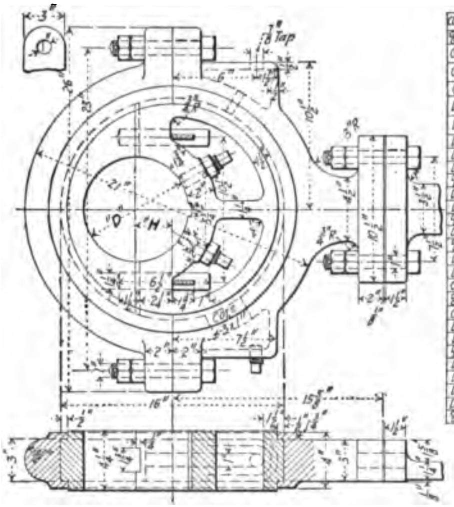

NOTE: Dimensions underlined thus — are out of scale
Cylinder Head Studs
Extended Stud for Back Cylinder Head and Casing 8 per Loco; Used in Holes "X"
Extended Stud for Back Steam Chest Head and Casing 8 per Loco; Used in Holes "Y"
Section A-B
Section C-D
Frame Keys, Top and Bottom Front only
Material:-Closed Grained Grey Iron Specification C.S.32 Cylinder Pattern No.L.1.4194 Cylinder Bushing Pattern No.C.A.7216

FIG. 377.—Showing Arrangement of Views on Cylinder Drawing.

TABULATED DIMENSIONS

It is possible on some lines of work to save labor in the drawing office by tabulating dimensions of such parts as are made in various sizes but to the same design. Thus the eccentric, Fig. 378, is made in many sizes but one drawing answers for all by the addition of a table giving the dimensions for each size of axle. There are only two dimensions on the work that differ and two columns, *D* and *H*, are therefore all that are required to carry the varying figures.



CLASS	ENGINES AND OLD NUMBERS		D	H
G.E.	20"x30"-12 Whl.	1901 to 1985	8"	2¾"
G.B.	20"/30"x26"-12 Whl.	1999 to 2006	7½"	2¾"
G.C.	20"/29"x26"-12 Whl.	1986 to 1998	7½"	2¾"
G.F.	20½"x26"-12 Whl.	1952 to 1960	7½"	2¾"
D.D.	20"/29"x24"-10 Whl.	1785 to 1789	7½"	3"
D.C.	20"/29"x26"-10 Whl.	1790 to 1793	7⅝"	3"
D.E.	19"x24"-10 Whl.	1787	7½"	2¾"
D.B.	19"x24"-10 Whl.	1794 to 1807	7½"	2¾"
D.K.	18"x24"-10 Whl.	1716 to 1725	7"	2¾"
[illegible]	18"x24"-10 Whl.	1658 to 1677	7½"	2¾"
D.L.	18"x24"-10 Whl.	1684 to 1693	7"	2¾"
D.O.	18"x24"-10 Whl.	1601 to 1657	7"	2¾"
[illegible]	18"x24"-10 Whl.	1584 to 1599	7"	2¾"
D.H.	18"x24"-10 Whl.	1746 to 1755	7½"	2¾"
[illegible]	18"x24"-10 Whl.	1684 to 1712	7"	2¾"
D.J.	18"x24"-10 Whl.	1726 to 1745	7½"	2¾"
D.G.	18"x24"-10 Whl.	1713 to 1715	7½"	2¾"
C.F.	18"x24"-8 Whl.	1402 to 1411	8"	2¾"
[illegible]	18"x24"-8 Whl.	1382 to 1401	7½"	2¾"
C.B.	18"x24"-8 Whl.	1370 to 1381	7½"	2¾"
B.A.	18"x24"-6 Whl.	1024 to 1047	7½"	2¾"
B.B.	18"x24"-6 Whl.	1014 to 1023	7½"	2¾"
[illegible]	18"x24"-10 Whl.	1566 to 1580	6¾"	2¾"
D.O.	18"x24"-10 Whl.	1581 to 1583	7"	2¾"
D.O.	18"x24"-10 Whl.	1554 to 1559	7"	2¾"
D.A.	20"x26"-10 Whl.	1810 to 1812	7½"	3"
D.M.	18"x24"-6 Whl.	1666 to 1668	7"	2¾"
[illegible]	17"x24"-8 Whl.	1304 to 1354	7"	2¾"

FIG. 378.—Eccentric and Table.

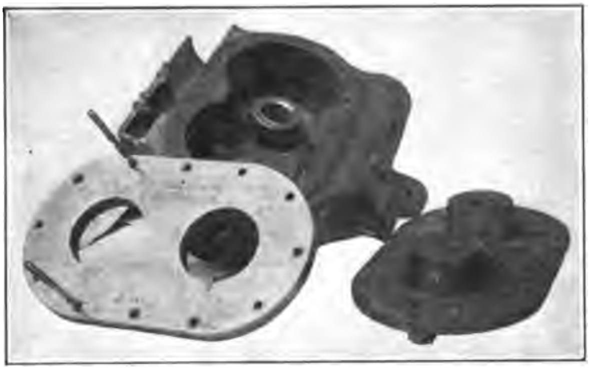


FIG. 379.—Gear Pump and Jig. See Pump Drawing Fig. 380.

Draw this eccentric and strap and select any size of axle for diameter *D* and use the dimension in corresponding column for *H*.

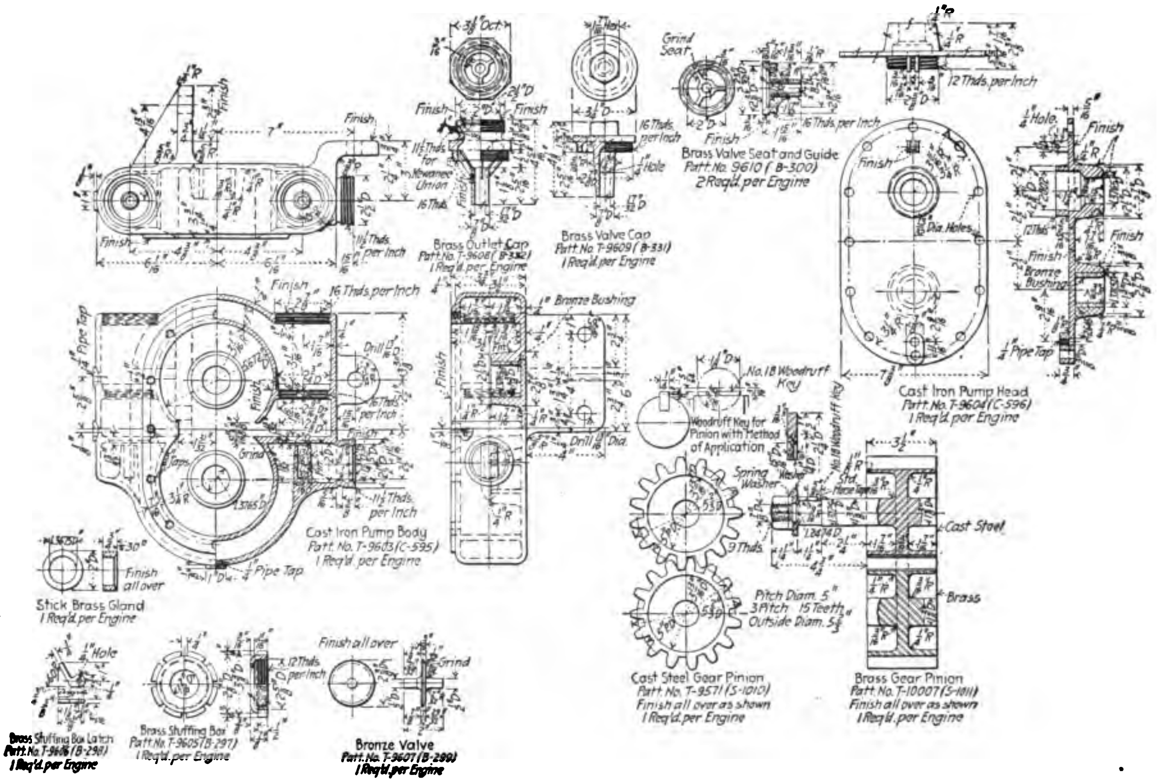


FIG. 380.—Detail Drawing of Geared Pump.

A GEAR PUMP

The gear pump in Fig. 379 is shown by detail drawings in Fig. 380.

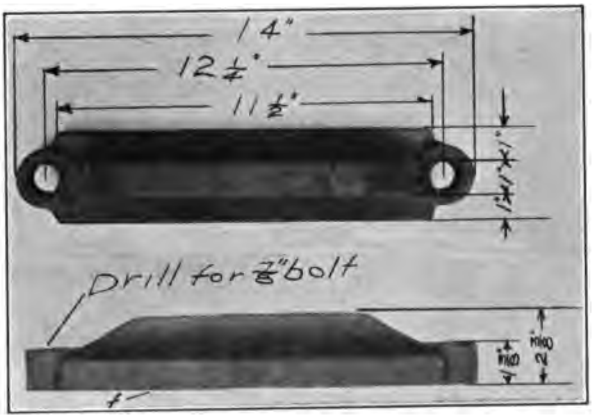


FIG. 381.—Cap for Box Support Shown in Fig. 382.

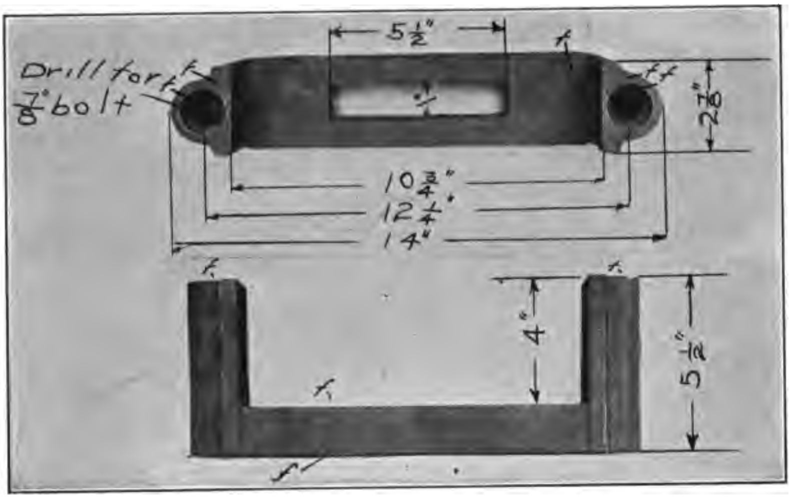


FIG. 382.—Box Support Using Cap Shown in Fig. 381.

The photograph contains at the front a jig plate which is used for drilling the holes for the cover plate screws or studs. As this jig is marked it should cause no confusion when the photograph is examined.

MISCELLANEOUS

Figs. 381 to 390 illustrate photographically a variety of machine parts on which enough dimensions are given to enable them to be drawn satisfactorily.

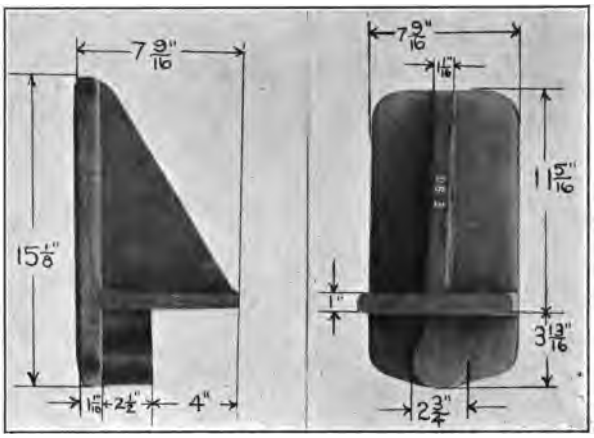


FIG. 383.—A Cast Bracket.

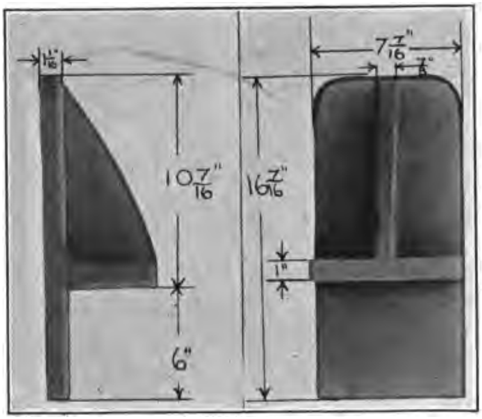


FIG. 384.—Another Design of Bracket.

Draw three views of each part here represented, showing at least one section in each case.

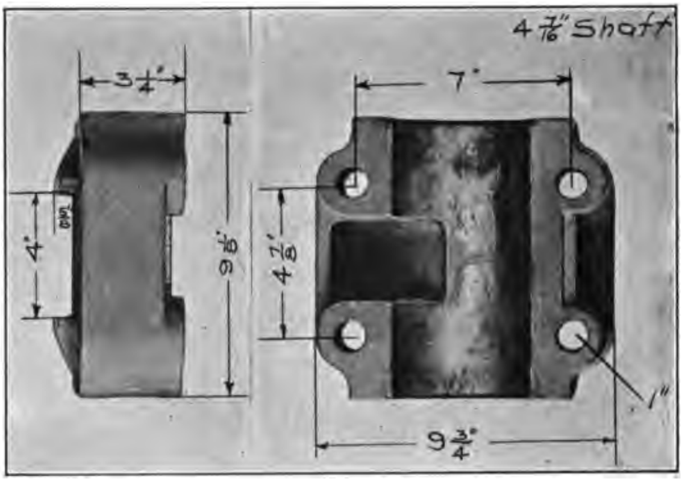


FIG. 385.—Heavy Shaft Box.

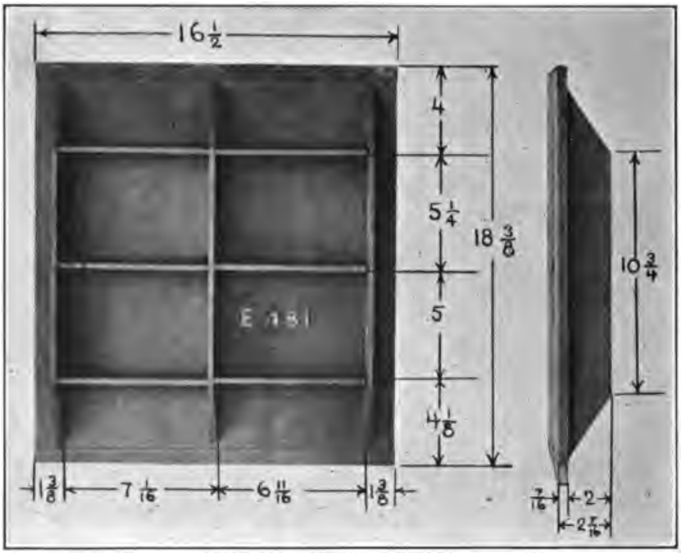


FIG. 386.—Surface Plate.

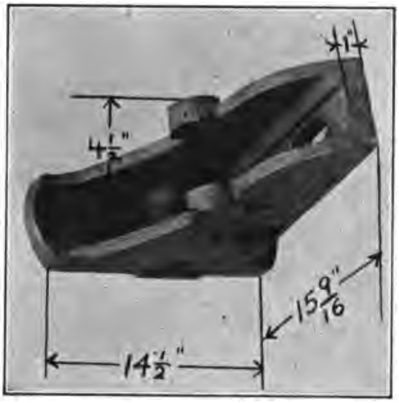


FIG. 387.—An Angle Casting.

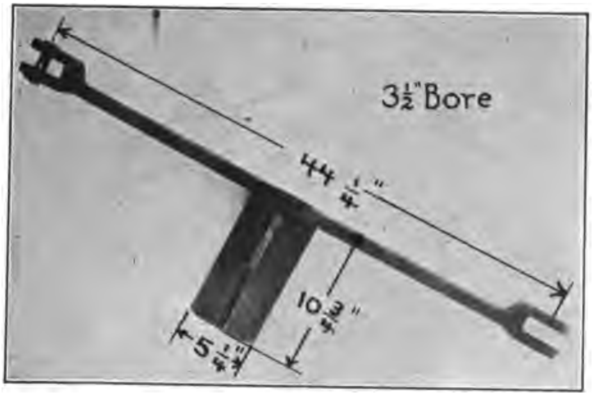


FIG. 388.—A Rocker Arm.

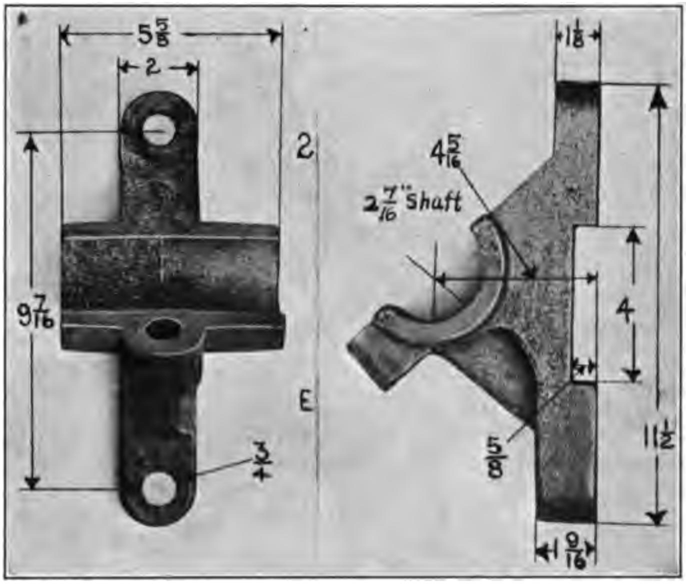


Fig. 389.—Wall Bearing for Shaft.

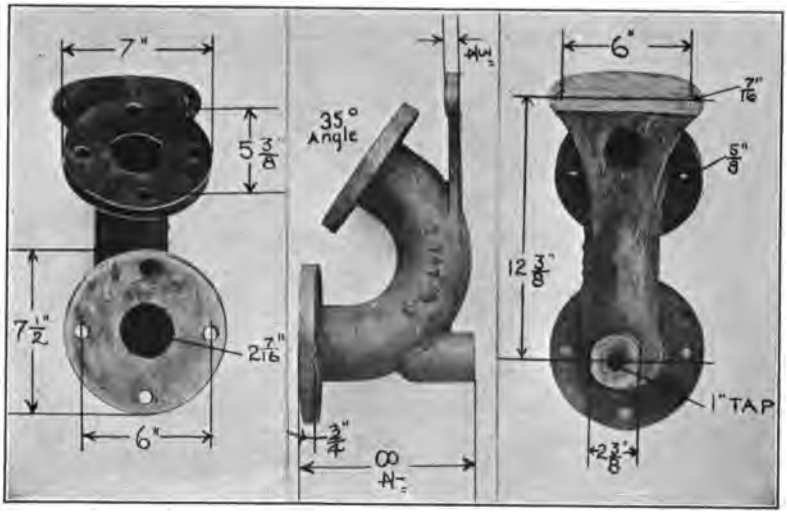


Fig. 390.—Steam Pipe Elbow with Bracket Connections.

CHAPTER X

WORKING DRAWINGS OF SMALL AND MEDIUM-SIZED PARTS

The drawings in this chapter are principally of such small work as typewriter parts, and other small and medium-sized mechanical details. They are presented in this special chapter to bring out certain features in regard to dimensioning and notation which oftentimes form definite problems on small drawings where little space is available for any great number of dimension lines and figures.

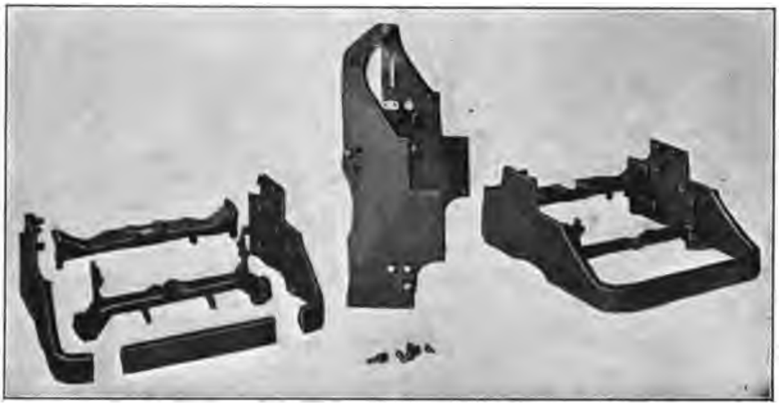


FIG. 391.—A Typewriter Frame Assembled and Taken Apart.

Fig. 391 illustrates a group of five castings which when finished and assembled form a typewriter frame; the frame assembled is shown at the center and right in the engraving. An assembly drawing is reproduced in Fig. 392. The two side plates or right and left side frames are shown in detail by the drawings Figs. 393 and 394 respectively. The front frame brace and rear frame brace are represented by the drawings Figs. 395 and 396.

Note in Figs. 393 and 394 the method of giving important dimensions vertically from the bottoms of the small feet at the under side of the frame. Also note the dimensioning of the main group of holes in the side frames from the base hole *A* so that all holes in this group will be accurately located in respect to hole *A* and therefore in correct relation to each other.

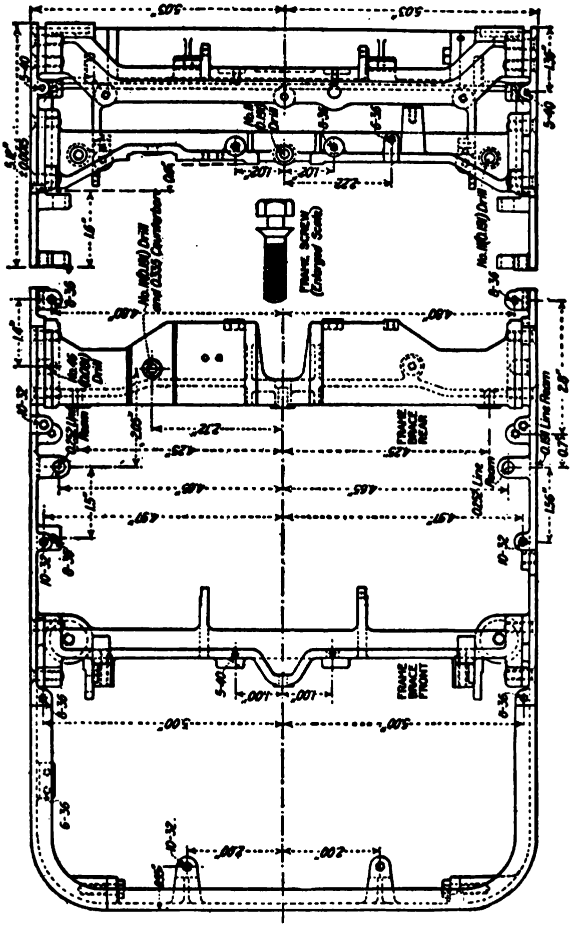


Fig. 392.—Drawing of Typewriter Frame.

Note in the assembly drawing, Fig. 392, the common center line through the assembled frame with dimensions each way to the holes in the lugs of the side plates. Thus the correct distance is established between the hole centers in the side plates when these plates are assembled into the frame.

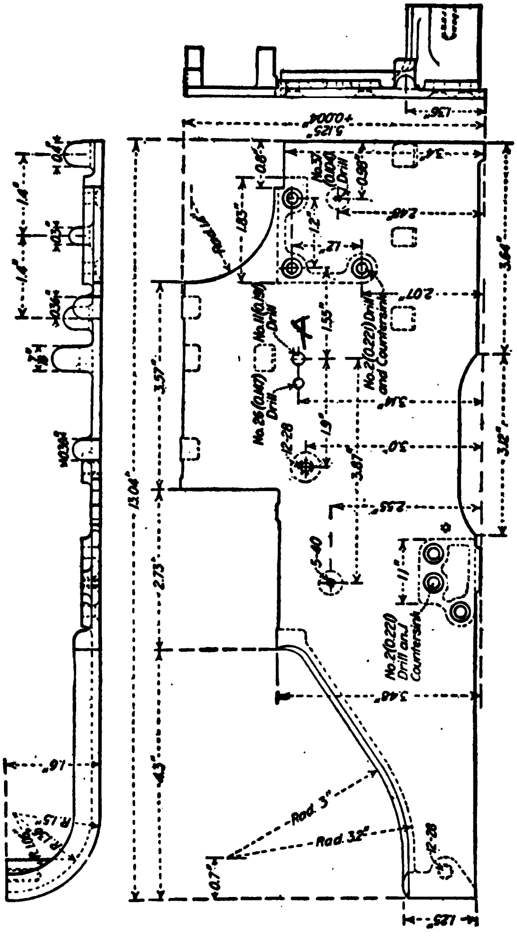


FIG. 393.—One of the Side Plates. (Right-hand Side.)

SHEET METAL PARTS

The sheet metal part in Fig. 397 is known as a universal bar and is used on the same make of typewriter. This drawing shows at the top of the sheet the blanked work as it comes from the punch press ready for forming up to the finished shape shown at the bottom of the drawing. This method of showing the blank on the drawing enables the die maker to make his punches and dies to the dimensions given on the blueprint without the necessity of working back from a formed sample to the straight blank.

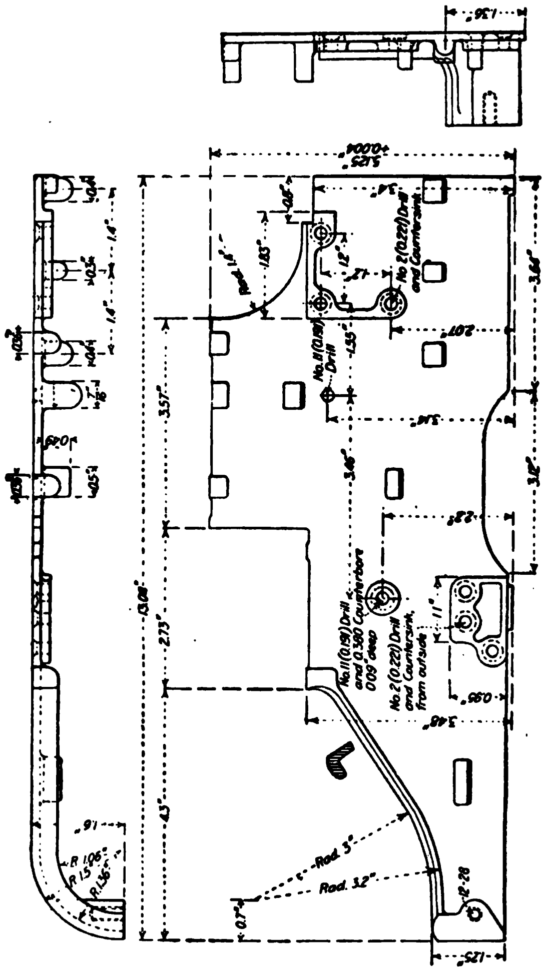


FIG. 394.—The Left Side Plate.

Note that the dimensions on the blank as well as on the formed piece are given from the center line.

The notched comb drawing, Fig. 398, is of interest as showing the dimensioning of a piece where many angular distances must be given; all notches here being spaced apart either 3½ or 4 degrees.

Fig. 399 is a drawing of a bell crank which is made up in various angles of offset and both right and left hand. In order to avoid the making of separate drawings of each and every bell crank the respective offsets are indicated by dotted lines in the finished or "formed" drawing at the left of the sheet, and a table is given on the drawing stating how many must be made right hand and left hand and how many of each hand must be made straight, how many to the first offset, how many to the second offset and so on.

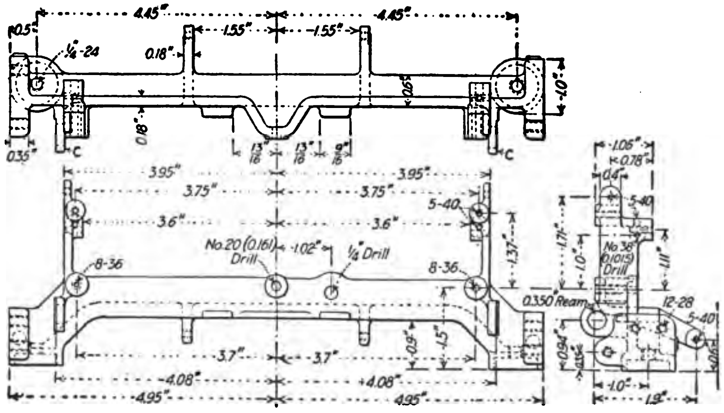


Fig. 395.—The Front Frame Brace.

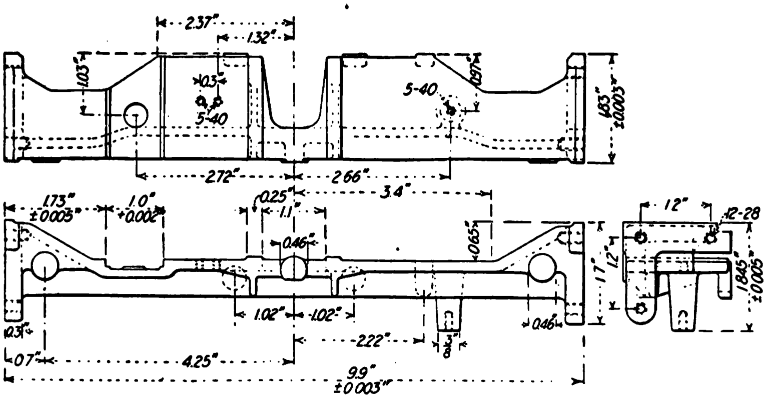


Fig. 396.—The Rear Frame Brace.

Where small parts are made in a variety of sizes although of the same general design, it is usually safer to make a

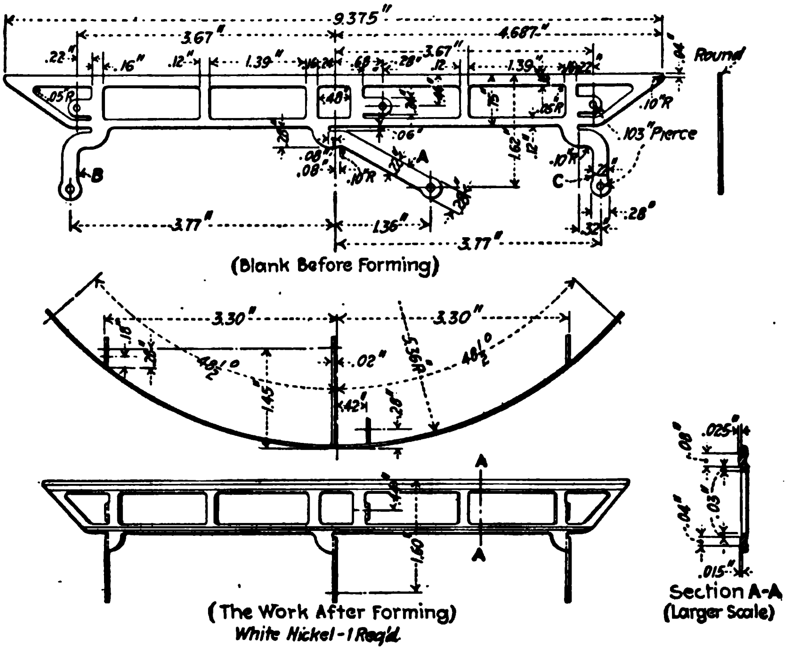


Fig. 397.—Drawing of Universal Bar for Typewriter.

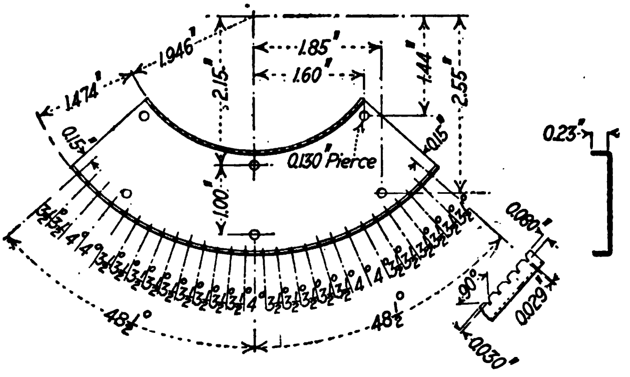


Fig. 398.—A Notched Comb for Type Bars.

separate drawing of each although if only a few dimensions are required a table is generally sufficient as a single drawing may then be used with letters on the dimension lines and the table laid out to give the different values of each dimension on the different sizes.

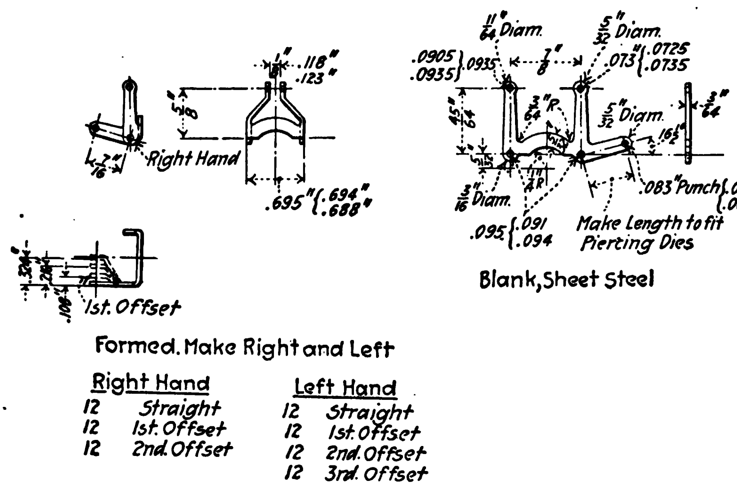


FIG. 399.—Details of Bell Crank for Typewriter.

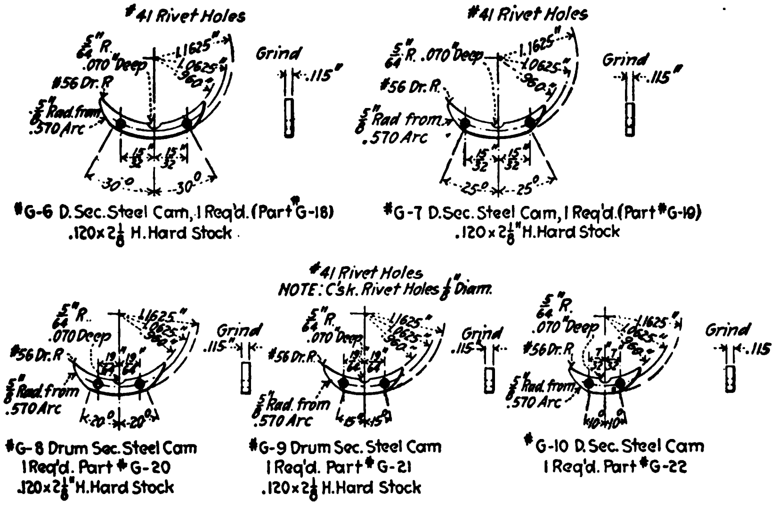


FIG. 400.—Details of a Set of Steel Cams.

But with numerous dimensions necessary it is better to draw each size of piece separately and give each drawing complete dimensions. Thus in Fig. 400 a series of steel cams are drawn which are all of one general design but which differ in respect to over all length and center distance between rivet holes. While these cams might have been shown by a single drawing and a table of dimensions, the present drawing with separate layout for each size of cam is far preferable for the tool maker who makes the dies for the job. There is no chance of confusion in working from the complete drawing and as so many cams may be placed on the one sheet the little extra work necessary upon the part of the draftsman is well justified in the later saving in the tool room.

SIMPLIFYING DIMENSIONS

On small parts and particularly where dimensions must run into three or four place decimals there is always danger of so crowding figures onto details as to make the drawing anything but intelligible to the user. Sometimes the device is adopted of making the drawing double actual size or even larger but this is not always desirable.

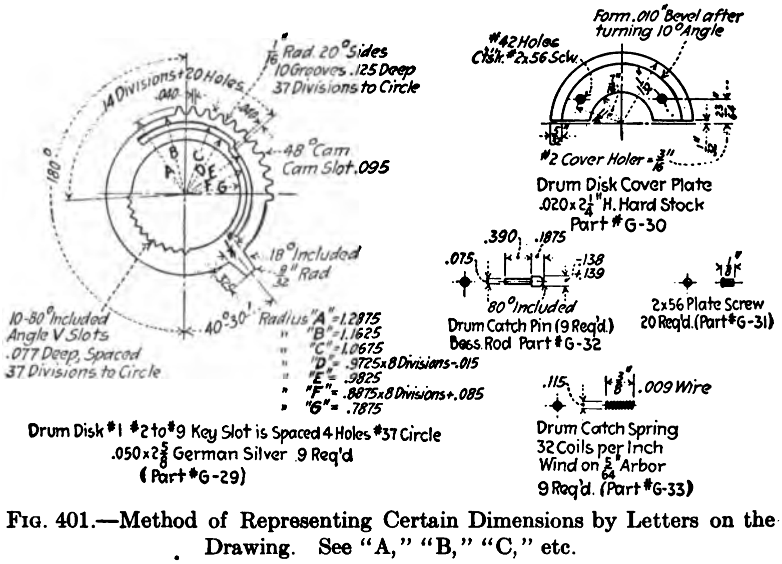


Fig. 401.—Method of Representing Certain Dimensions by Letters on the Drawing. See "A," "B," "C," etc.

One way of getting around such a difficulty is to designate the dimensions in a crowded group by letters only as in Fig. 401. (See detail to the left.) Then place a table under the detail with the actual dimensions corresponding to the letters referred to. Thus in the case of the toothed cam disk at the left of Fig. 401 all dimensions relating to the cam slot, the bore and the top and bottom of the teeth are designated by letters *A* to *G*. Then the actual dimensions corresponding thereto are given in the table below the drawing.

The chapter which follows on "Tool Drawings" also includes information on small details that should be of interest to those laying out small and medium-sized work.

CHAPTER XI

TOOL DRAWINGS

So much of the work of the draftsman to-day is along the line of special tool drawing that a chapter may well be devoted to the subject. It is not the intention however to show here complete details of jig and fixture parts and other special tool standards as complete data on such parts will be found in the "American Machinists' Handbook," and in the volume on "Jigs and Fixtures." It is more the purpose of this chapter to illustrate a variety of tool drawings for general information and for practice for the user of this book. For full details of standard dimensions of bushings, straps, binders, handles, clamps, cutters, reamers, drill shanks and drills, and other parts see the volumes referred to above. For punch and die standards and complete details of press tools, refer to the volume on "Punches and Dies."

REAMERS AND TAPS

Fig. 402 is a drawing of a reamer for general work in locomotive shops. This reamer is made with a long taper portion to enter the work before the full body diameter is reached. The reamer differs from the common shop reamer in respect to this tapered lead. The table gives the dimensions for various sizes of reamers and it will be good practice to lay out two or three sizes from the tabulated data. It will be noticed that the shank which is made to the Morse taper, is not provided with dimensions but is known by number instead. This is the usual practice in regard to all tools with standard taper shanks. Refer to the table of Morse Tapers in the "American Machinists' Handbook" for complete dimensions of all sizes of taper shanks for such tools.

Fig. 403 is a drawing of a bolt shop tap with full dimensions in the table at the side.

BORING TOOL FOR THE LATHE

The drawing in Fig. 404 is of a boring tool for the lathe. The bar proper is 2 inches diameter and is carried in a block which is bolted to the tool slide on the carriage in place of the regular tool post. There is a tongue on the underside of the block to fit the slot in the top of the tool slide or cross slide of the carriage.

REAMERS FOR GENERAL WORK

A	B	C	D	E	F
1/4"	6 1/8"	#1	3 1/16"	5/32"	1 1/2"
5/16"	6 3/16"	#1	3 9/16"	3/16"	1 1/2"
3/8"	7 1/4"	#1	4 1/16"	7/32"	2"
7/16"	8 1/4"	#2	4 9/16"	1/4"	2"
1/2"	9"	#2	5 1/4"	5/16"	2 1/2"
9/16"	9"	#2	5 1/4"	3/8"	2 1/2"
5/8"	10"	#2	6 1/4"	3/8"	2 1/2"
11/16"	11"	#3	6 5/8"	3/8"	3 1/2"
3/4"	12"	#3	7 5/8"	7/16"	3 1/2"
13/16"	12"	#3	7 5/8"	1/2"	3 1/2"
7/8"	12"	#3	7 5/8"	9/16"	3 1/2"
15/16"	12"	#3	7 5/8"	5/8"	3 1/2"
1"	12"	#3	7 5/8"	11/16"	3 1/2"
1 1/16"	12"	#3	7 5/8"	3/4"	3 1/2"
1 1/8"	12"	#3	7 5/8"	13/16"	3 1/2"
1 3/16"	12"	#3	7 5/8"	7/8"	3 1/2"

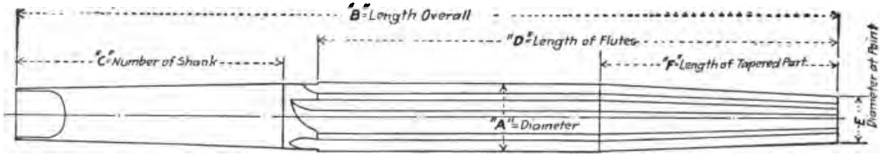


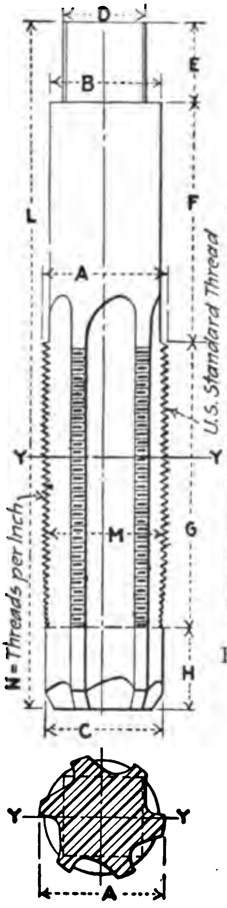
FIG. 402.—Reamer Drawing with Tabulated Dimensions.

Draw a tool of this kind and change the dimensions to fit some lathe which can be measured for size of tool rest, proportions of slot, etc. A block of this kind with a boring bar of

$\frac{1}{2}$-inch diameter is a very convenient tool for general use in the tool room and for shop use on small work.

A SLOTTER TOOL

The slotter tool in Fig. 405 has two adjustable cutters or tool points and these are set to a gage as shown in the upper right-hand corner or a caliper or micrometer may be used. The two tools are placed in the holder at an angle to both horizontal and vertical planes. Measure these angles with the protractor and draw the square tools in the proper position.



A	N	L	B	C	D	E	F	G	H	M
2"	8	17"	1 3/4"	1.783"	1 1/4"	1 1/4"	6 3/4"	7"	2"	1.837
2 1/4"	8	17"	2	2.033"	1 7/16"	1 7/16"	6 9/16"	7"	2"	2.087
2 3/8"	8	17"	2 1/8"	2.158"	1 9/16"	1 9/16"	6 7/16"	7"	2"	2.212
2 1/2"	8	17"	2 1/4"	2.283"	1 5/8"	1 5/8"	6 3/8"	7"	2"	2.337
2 1/2"	10	17"	2 1/4"	2.327"	1 5/8"	1 5/8"	6 3/8"	7"	2"	2.36
2 1/2"	4	17"	2"	2.067"	1 7/16"	1 7/16"	6 9/16"	7"	2"	2.176
3"	8	17"	2 3/4"	2.783"	2"	2"	6"	7"	2"	2.837
3 7/16"	8	17"	3 3/16"	3.221"	2 1/4"	2 1/4"	5 3/4"	7"	2"	3.27
3 11/16"	8	17"	3 7/16"	3.471"	2 7/16"	2 7/16"	5 9/16"	7"	2"	3.525
3 3/4"	8	17"	3 1/2"	3.533"	2 1/2"	2 1/2"	5 1/2"	7"	2"	3.587

FIG. 403.—Machine Tap—with Table of Dimension on Drawing.

TURRET LATHE TOOLS

The boring bar and tools in Fig. 406 are for finishing piston valve rings in the turret lathe. The drawing of this tool

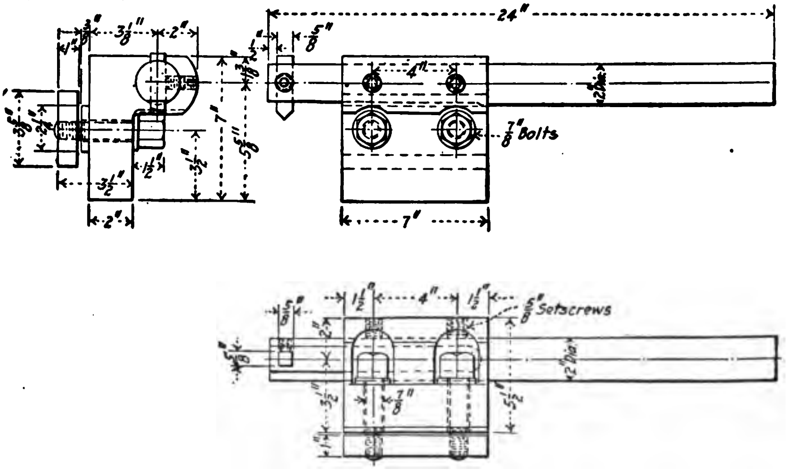


FIG. 404.—Drawing of a Boring Bar.

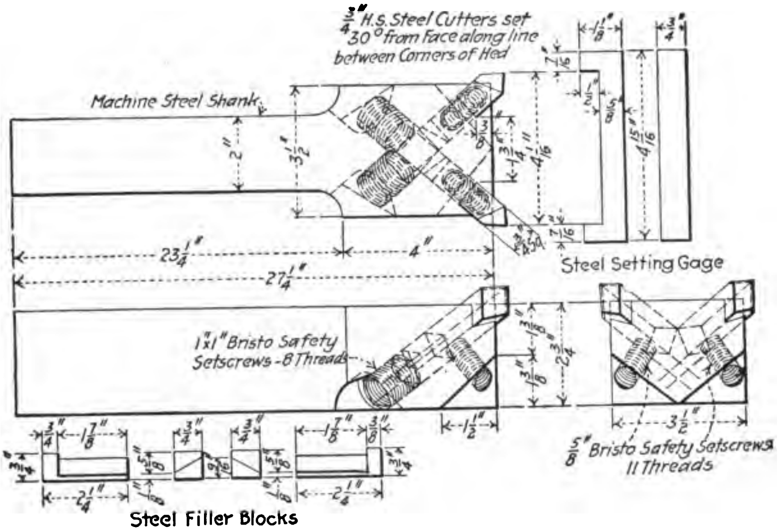

3/4" H.S. Steel Cutters set 30° from Face along line between Corners of Head
Machine Steel Shank
Steel Setting Gage
1×1" Bristo Safety Setscrews - 8 Threads
5/8" Bristo Safety Setscrews 11 Threads
Steel Filler Blocks
23 1/4"
27 1/4"
4"

FIG. 405.—Details of an Adjustable Slotter Tool

equipment is reproduced in Fig. 407. This drawing shows an assembly complete of the boring head and an enlarged

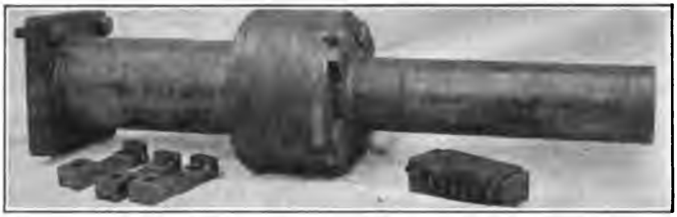


FIG. 406—Boring Bar for Turret Lathe. See Drawing, Fig. 407.

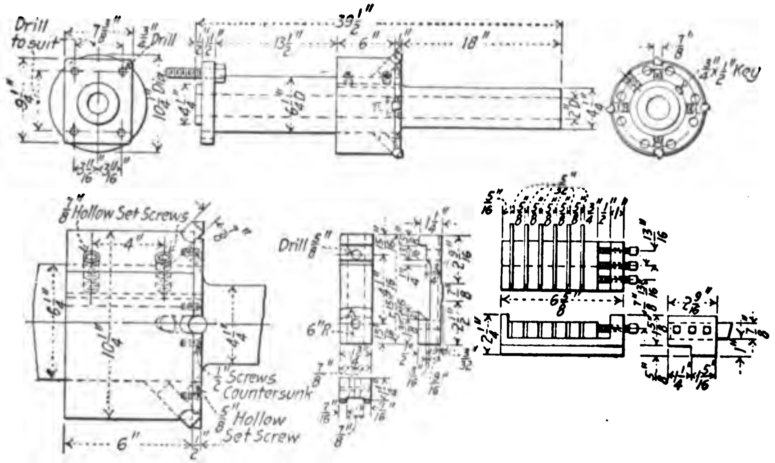

Drill to suit
$\frac{3}{4}$" Drill
$39\frac{1}{2}$"
$13\frac{1}{2}$"
6"
18"
$\frac{3}{4}$"×$\frac{1}{2}$" Key
$\frac{7}{8}$" Hollow Set Screws
4"
Drill $\frac{5}{8}$"
6" R.
$\frac{1}{2}$" Screws Countersunk
$\frac{5}{8}$" Hollow Set Screw
6"

FIG. 407.—Details of Boring Bar and Tools for Piston Rings.

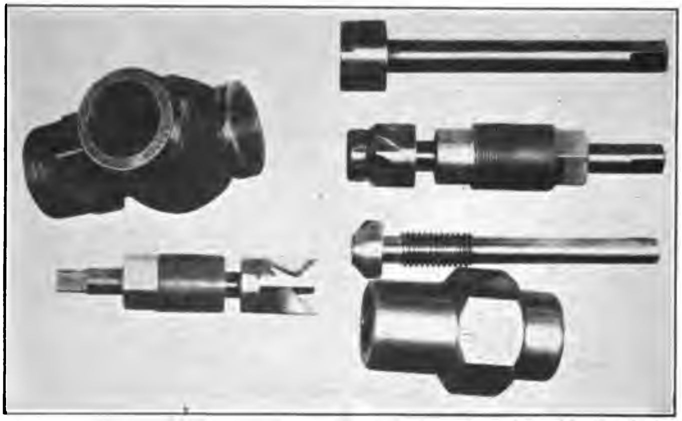


FIG. 408.—Hand Reamers for Air Pump Throttle Valve and Seat. See Drawing, Fig. 409.

view of the head alone. The details at the lower right-hand corner show the six cutting off tools in their holder.

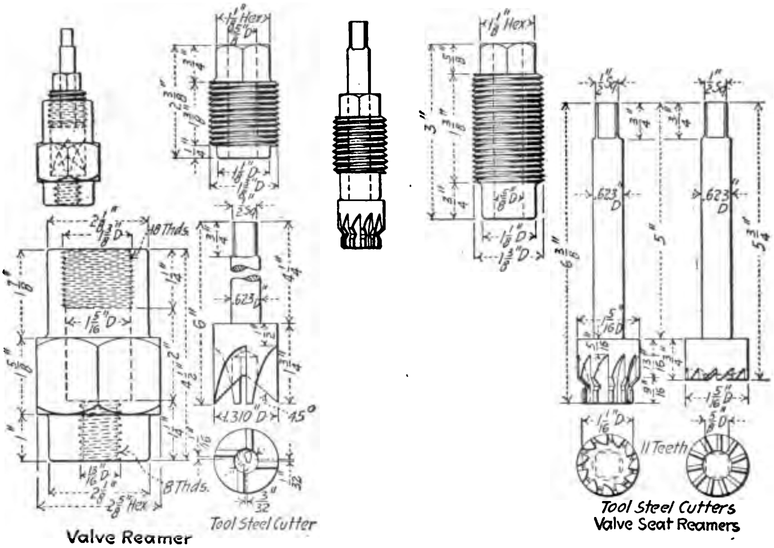


Fig. 409.—Detail Drawing of Reamer for Air Pump Throttle Valve and Seat.

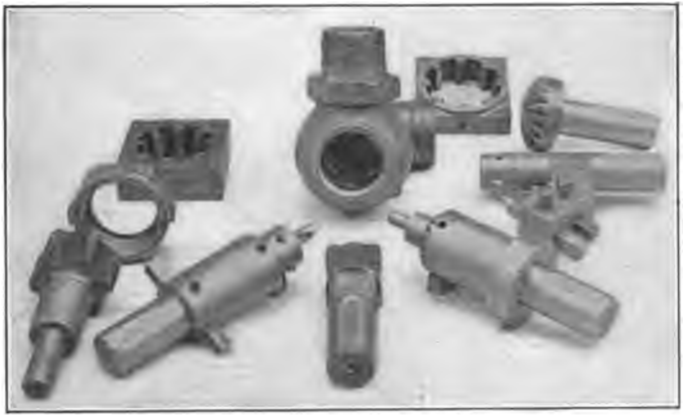


Fig 410.—Tools for Boiler Check Valve Bodies. See Drawing, Fig. 411.

VALVE SEAT TOOLS

The photographic group in Fig. 408 illustrates a set of reamers for an air pump throttle valve and valve seat. Details of these tools are drawn up as in Fig. 409. Note the neat arrangement of details so that the sleeves are shown adjacent to the tools with which they are used.

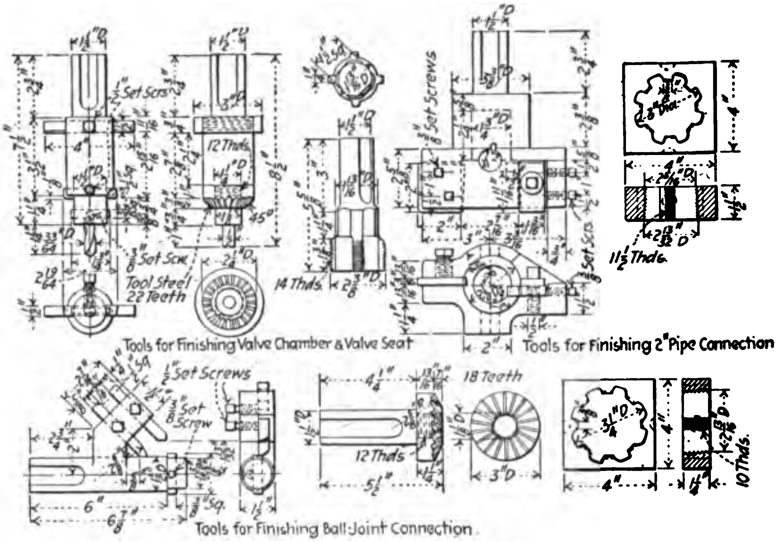


FIG. 411.—Arrangement of Details on Drawing of Check Valve Tools

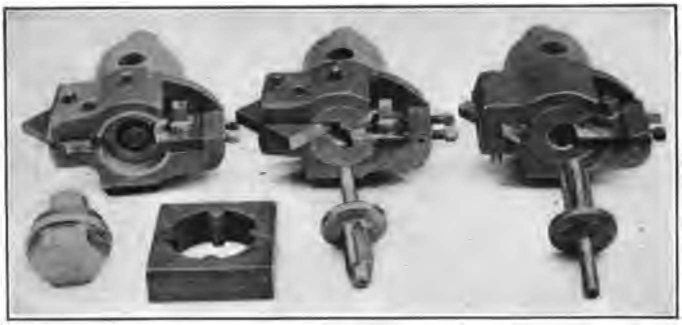


FIG. 412.—Tools for Check Valve Fittings. See Drawing, Fig. 413.

The tools in Fig. 410 are shown in the detail drawing, Fig. 411. This set of tools is made for the brass lathe and used for finishing boiler check valve bodies. The tools in Figs. 412 and 413 are of the box tool order and are used for finishing the fittings for check valves. They are therefore part of the same outfit as shown in Figs. 410 and 411.

Compare the two photographs with the corresponding drawings and note the general arrangement of the details in the drawings to make all tools in the set as clear and distinct as possible. Turret tools of the general kind shown by both drawings are applicable to many lines of work and the detail layouts form excellent examples for study and practice in drawing and dimensioning equipment of this character.

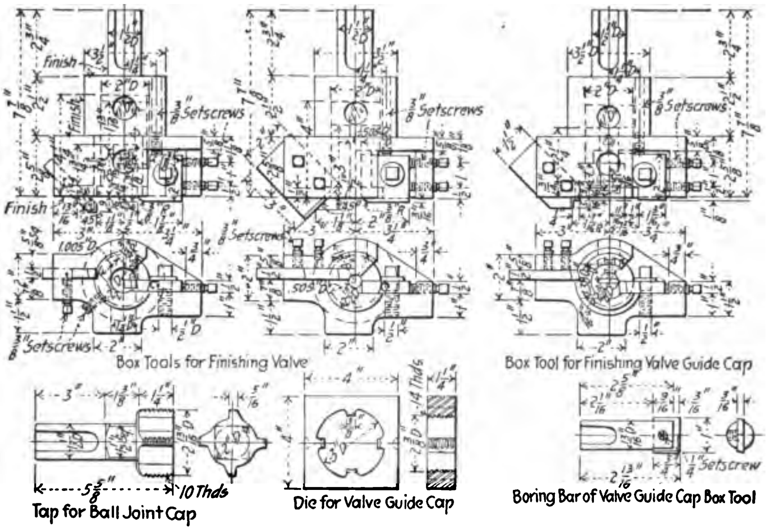

Box Tools for Finishing Valve
Box Tool for Finishing Valve Guide Cap
Tap for Ball Joint Cap
Die for Valve Guide Cap
Boring Bar of Valve Guide Cap Box Tool

FIG. 413.—Details of Tools for Check Valve Fittings.

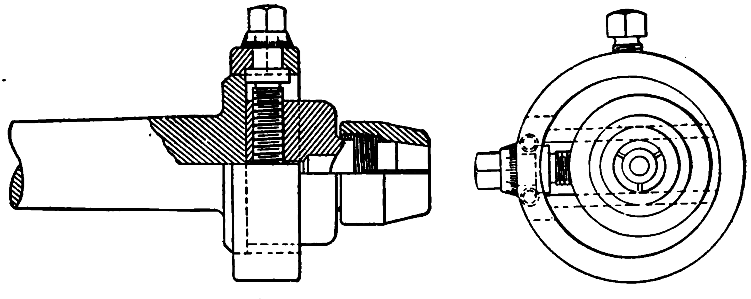


FIG. 414.—Boring Tool for the Milling Machine. See Fig. 415.

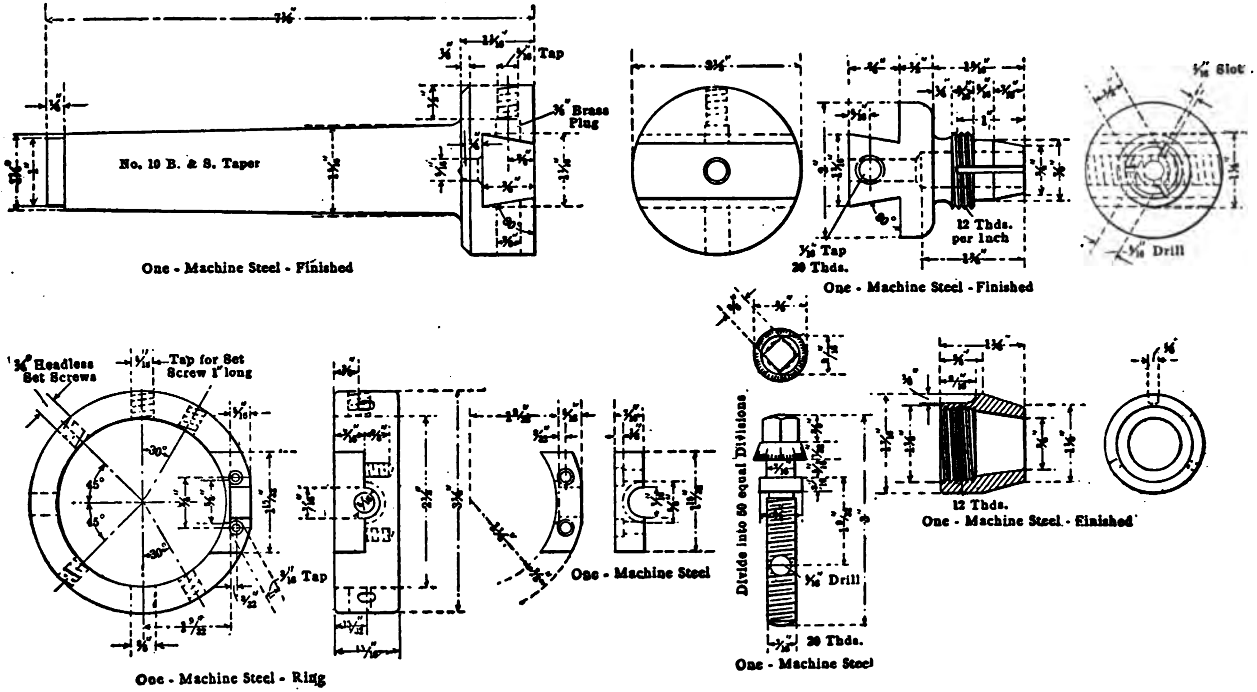

No. 10 B. & S. Taper
Tap
Brass Plug
One - Machine Steel - Finished
Tap
30 Thds.
12 Thds. per inch
One - Machine Steel - Finished
Slot
Drill
Headless Set Screws
Tap for Set Screw 1" long
30°
45°
45°
30°
Tap
One - Machine Steel - Ring
One - Machine Steel
Divide into 50 equal Divisions
Drill
30 Thds.
One - Machine Steel
12 Thds.
One - Machine Steel - Finished

FIG. 415 —Details of Boring Tool for the Milling Machine

BORING TOOL FOR THE MILLING MACHINE

This boring tool is shown in assembly drawing in Fig. 414. Details are given on the drawing Fig. 415. In drawing this tool find details of taper shank size in the Brown & Sharpe taper shank table in the "American Machinists' Handbook."

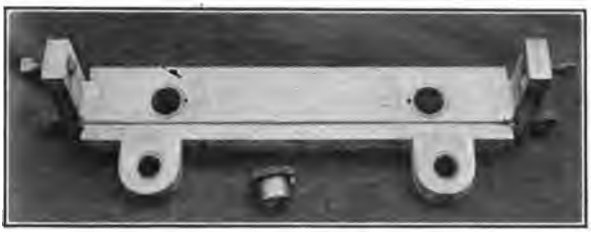


FIG. 416.—Reversible Drill Jigs for Eccentrics. See Drawing, Fig. 417.

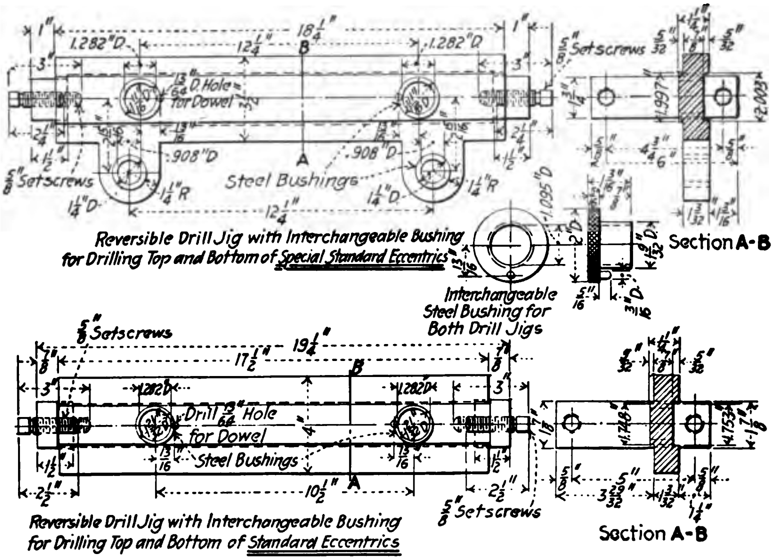

1.282"D
$18\frac{1}{4}''$
$12\frac{1}{4}''$
B
1.282"D
$\frac{5}{8}''$ Setscrews
$\frac{13}{64}''$ D. Hole for Dowel
.908"D
A
.908"D
Steel Bushings
$1\frac{1}{4}''$R
$1\frac{1}{4}''$D
$\frac{5}{8}''$ Setscrews
1.997
2.003
1.095"D
Section A-B
Reversible Drill Jig with Interchangeable Bushing for Drilling Top and Bottom of Special Standard Eccentrics
Interchangeable Steel Bushing for Both Drill Jigs
$\frac{5}{8}''$ Setscrews
$19\frac{1}{4}''$
$17\frac{1}{2}''$
B
1.282D
Drill $\frac{13}{64}''$ Hole for Dowel
Steel Bushings
$10\frac{1}{2}''$
A
$\frac{5}{8}''$ Setscrews
1.748
1.753
Section A-B
Reversible Drill Jig with Interchangeable Bushing for Drilling Top and Bottom of Standard Eccentrics

FIG. 417.—Drawing of Drill Jigs for Eccentrics.

DRILLING AND BORING JIGS

The drill jig in Fig. 416 is one of a pair for eccentric drilling, complete drawings of both being given in Fig. 417.

The drill bush is interchangeable between both jigs and is slipped into steel liner bushings permanently fixed in each jig.

This is a simple type of jig for practice work in drawing special tools.

Fig. 418 is a drawing of an engine lathe apron, and Fig. 419 a drawing of a boring jig which is used for machining the lathe apron under a drill spindle. This type of jig is known as an open box jig and in the drawing the work is distinctly shown in the jig by means of heavy dot and dash lines. This is the usual method of showing the work in a jig or fixture. The various bushings for the cutter bars are here drawn in on the same sheet as the apron jig itself in Fig. 419. This is not always done, practice depending upon the number of details to be shown and the amount of space available. As a rule it is preferable where there are many details to make a separate drawing for bushings, bars, clamps, etc.

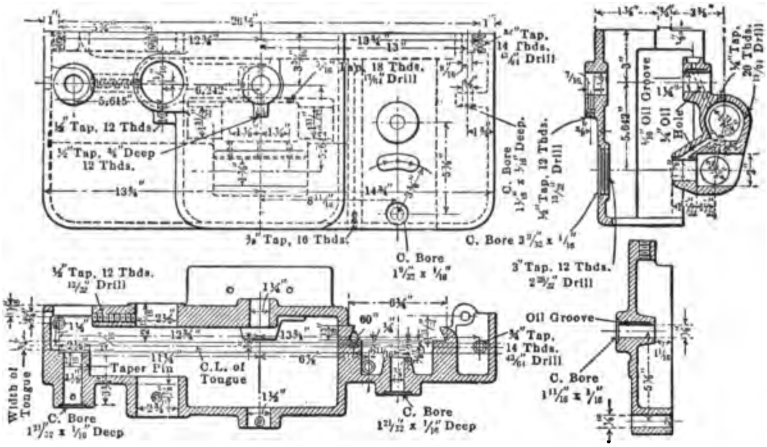

1/2" Tap, 12 Thds.
1/2" Tap, 3/4" Deep 12 Thds.
18 Thds. 17/64" Drill
3/4" Tap. 14 Thds. 43/64" Drill
C. Bore 1 1/16" x 1/16" Deep.
1/2" Tap, 12 Thds. 13/32" Drill
5/8" Oil Groove
1/4" Oil Hole
3/4" Tap. 20 Thds. 11/16" Drill
3/8" Tap, 16 Thds.
C. Bore 1 9/32" x 1/16"
C. Bore 3 3/32" x 1/16"
3" Tap. 12 Thds. 2 29/32" Drill
1/2" Tap, 12 Thds. 13/32" Drill
Oil Groove
3/4" Tap. 14 Thds. 43/64" Drill
C. Bore 1 11/16" x 1/16"
Taper Pin
C.L. of Tongue
Width of Tongue
C. Bore 1 21/32 x 1/16" Deep
C. Bore 1 21/32 x 1/16" Deep
60°
5.615"
6.242"
5.642"

Fig. 418.—Apron for 25-inch Lathe.

With this set of drawings there are two such extra sheets for the boring and reaming tools and for long boring bars. These drawings are reproduced in Figs. 420 and 421.

Study all details carefully and note the clear manner in which bushings, bars and cutters are brought out in the drawings.

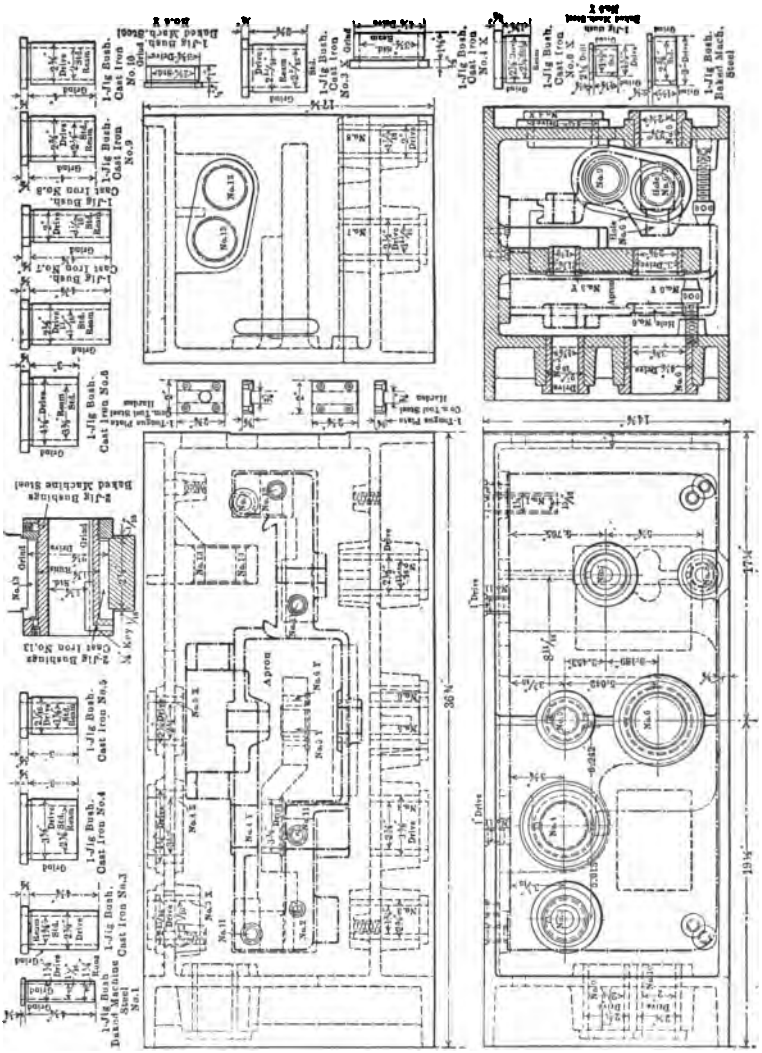


Fig. 419.—Apron Jig Drawing Showing Work in Heavy Dotted Lines.

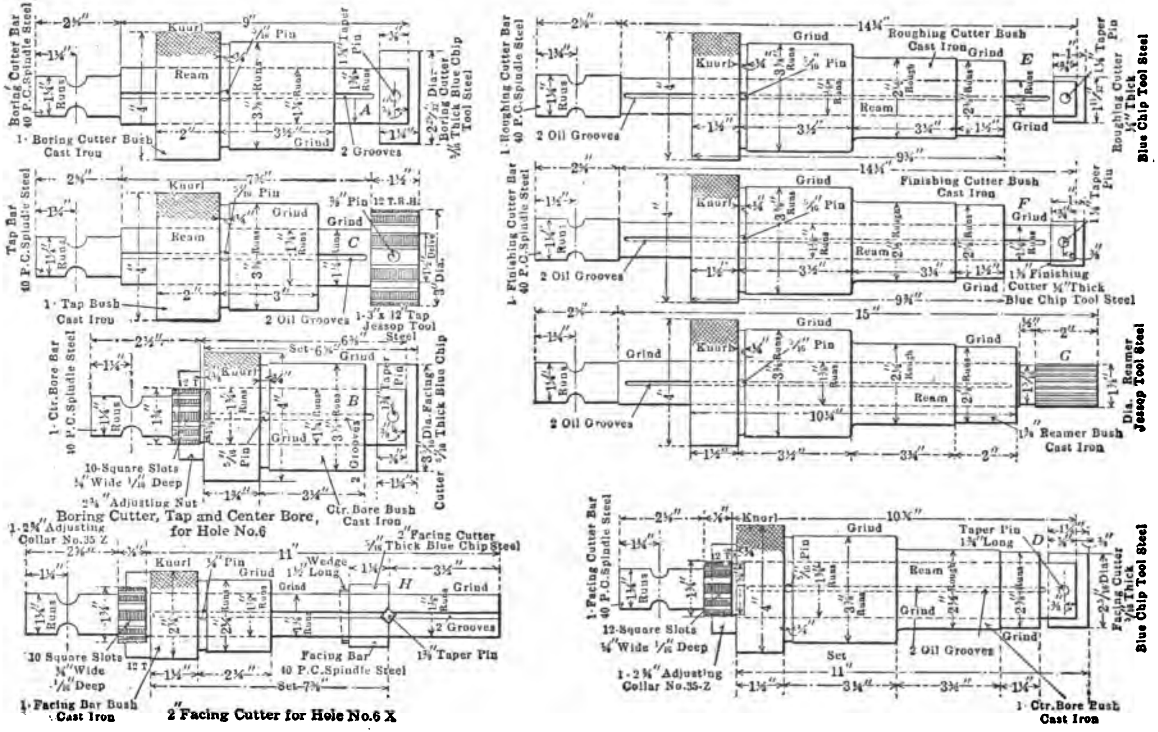

1-Boring Cutter Bar 40 P.C.Spindle Steel
1-Boring Cutter Bush Cast Iron
2-27/32" Dia. Boring Cutter 5/16" Thick Blue Chip Tool Steel
A
Tap Bar 40 P.C.Spindle Steel
1-Tap Bush Cast Iron
1-3/4" x 12 Tap Jessop Tool Steel
C
1-Ctr.Bore Bar 40 P.C.Spindle Steel
10-Square Slots 1/4" Wide 1/16" Deep
2 3/8" Adjusting Nut
3 5/16" Dia. Facing Cutter 5/16" Thick Blue Chip
Ctr. Bore Bush Cast Iron
B
Boring Cutter, Tap and Center Bore, for Hole No.6
1-2 3/8" Adjusting Collar No.35 Z
2" Facing Cutter 5/16" Thick Blue Chip Steel
H
Facing Bar 40 P.C.Spindle Steel
1 3/8" Taper Pin
10 Square Slots 3/8" Wide 1/16" Deep
1-Facing Bar Bush Cast Iron
2" Facing Cutter for Hole No.6 X
1-Roughing Cutter Bar 40 P.C.Spindle Steel
Roughing Cutter Bush Cast Iron
E
Roughing Cutter 1/4" Thick Blue Chip Tool Steel
1-Finishing Cutter Bar 40 P.C.Spindle Steel
Finishing Cutter Bush Cast Iron
F
1 3/8" Finishing Cutter 1/4" Thick Blue Chip Tool Steel
1 3/8" Reamer Bush Cast Iron
G
Dia. Reamer Jessop Tool Steel
1-Facing Cutter Bar 40 P.C.Spindle Steel
12-Square Slots 1/4" Wide 1/16" Deep
1-2 3/8" Adjusting Collar No.35-Z
Taper Pin 1 3/4" Long
D
Facing Cutter 5/16" Thick Blue Chip Tool Steel
1-Ctr.Bore Bush Cast Iron
Knurl
Ream
Grind
Runs
2 Oil Grooves
2 Grooves
Pin

FIG. 420.—A Set of Tools for Apron Operations.

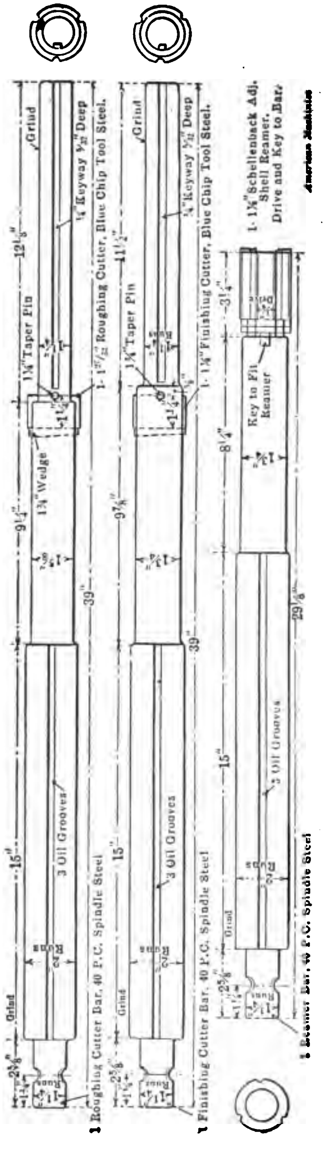

Grind
12 1/8"
1/4" Keyway 5/32" Deep
1 1/4" Taper Pin
1-1 27/32" Roughing Cutter, Blue Chip Tool Steel.
1 3/4" Wedge
9 1/4"
39"
15"
3 Oil Grooves
1 Roughing Cutter Bar, 40 P.C. Spindle Steel
11 1/2"
9 7/8"
1-1 3/4" Finishing Cutter, Blue Chip Tool Steel.
1 Finishing Cutter Bar, 40 P.C. Spindle Steel
1-1 3/4" Schellenback Adj. Shell Reamer. Drive and Key to Bar.
Key to Fit Reamer
3 1/4"
8 1/4"
29 1/8"
1 Reamer Bar, 40 P.C. Spindle Steel
American Machinist

FIG. 421.—Long Boring and Reaming Bars.

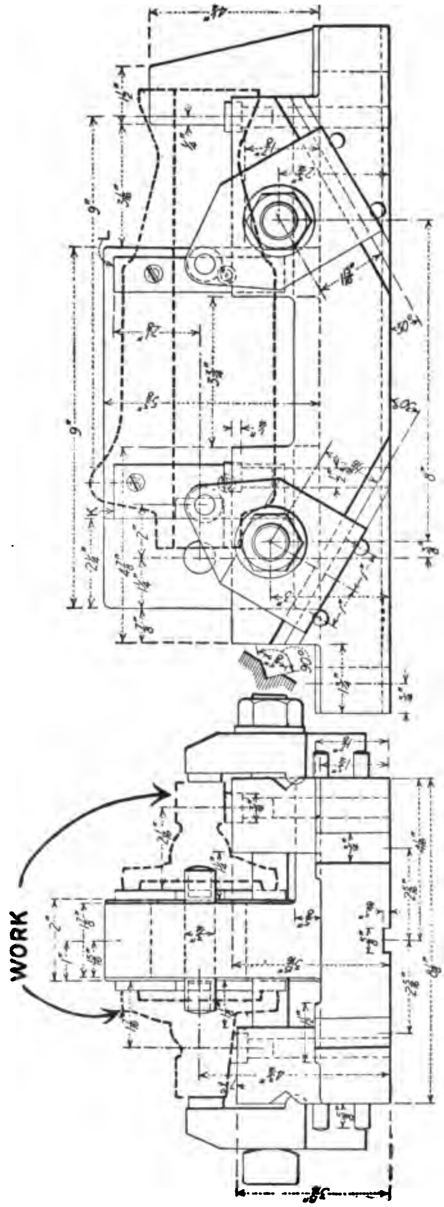


FIG. 422.—A Double Milling Fixture.

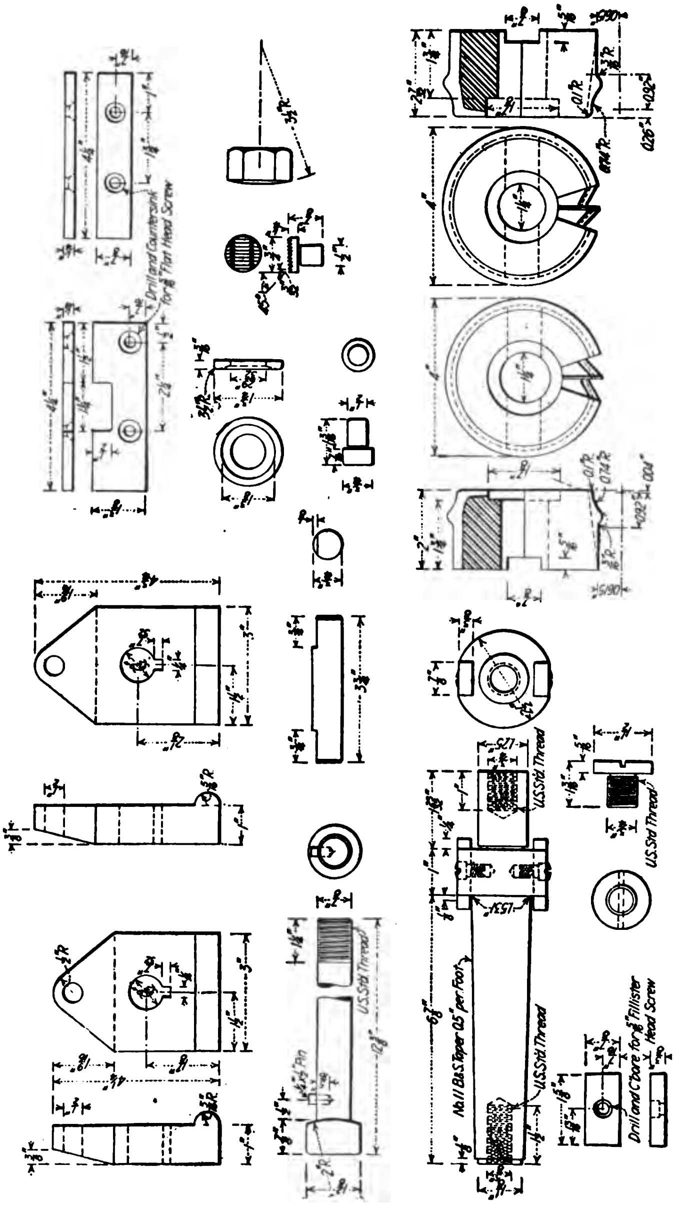

Drill and Countersink for 3/8" Flat Head Screw
U.S. Std. Thread
U.S. Std. Thread
U.S. Std. Thread
U.S. Std. Thread
No. 11 B.&S. Taper .05" per Foot
Drill and C'bore for 3/8" Fillister Head Screw

FIG. 423.—Details of Milling Fixture Shown in Fig. 422.

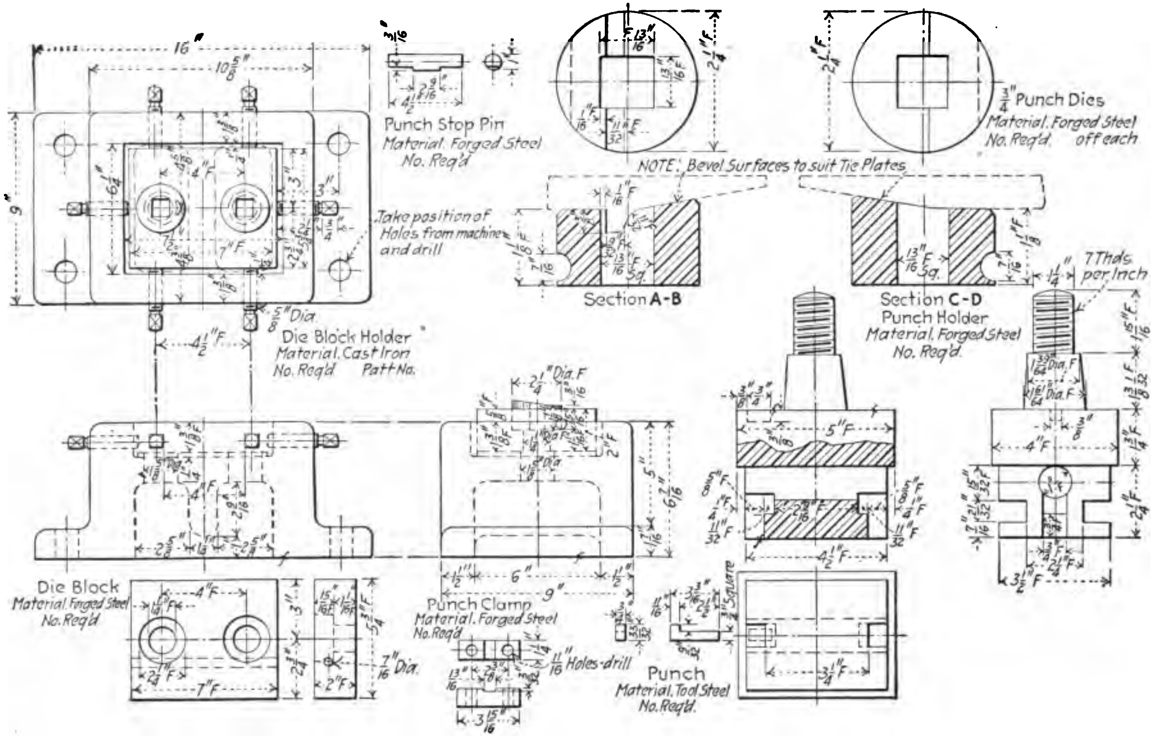
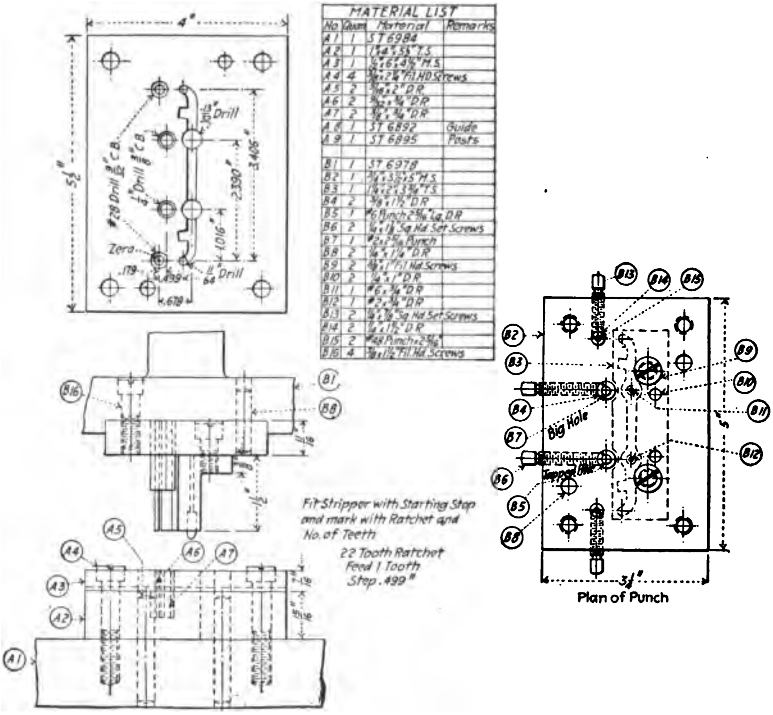


FIG. 424.—Detail Drawing of a Set of Punch Dies for Tie plates.

A MILLING FIXTURE

In milling fixtures as with drill jigs the work is usually shown by heavy dot or dot and dash lines. See Fig. 422. Here a receiver for a machine gun is shown in place on a straddle fixture for the milling of the flat surfaces on two pieces at one setting. Dimensions of the fixture proper are given on this drawing while all details are covered by the drawing, Fig. 423, which includes cutter arbor and cutters, as well.



MATERIAL LIST

No	Quan	Material	Remarks
A1	1	ST 6984	
A2	1	1¼"×4"×5½" T.S	
A3	1	½"×6"×4½" M.S	
A4	4	5/16"×2¼" Fil.Hd Screws	
A5	2	5/16"×2" D.R.	
A6	2	5/32"×¾" D.R	
A7	2	⅜"×¾" D.R	
A8	1	ST 6892	Guide
A9	1	ST 6895	Posts
B1	1	ST 6978	
B2	1	¾"×3½"×5" M.S	
B3	1	1¼"×2"×3¾" T.S	
B4	2	⅜"×1½" D.R	
B5	1	#6 Punch 2 5/16" Lg. D.R	
B6	2	¼"×1⅛" Sq. Hd. Set Screws	
B7	1	#2×1 5/16" Punch	
B8	2	¼"×1¼" D.R	
B9	2	5/16"×1" Fil. Hd. Screws	
B10	2	¼"×1" D.R	
B11	1	#6×¾" D.R	
B12	1	#2×¾" D.R	
B13	2	¼"×⅜" Sq. Hd. Set Screws	
B14	2	¼"×1½" D.R	
B15	2	#48 Punch×2 5/16"	
B16	4	5/16"×1½" Fil. Hd. Screws	

FIG. 425.—Drawing of Punch and Die for Typewriter Part shown in Fig 426. Note Material List.

PRESS TOOLS

A set of punch press dies and blocks is shown in the drawing, Fig. 424. This is a neatly detailed drawing and should be given considerable attention. Note particularly the sections showing the inside of the punch holder, etc.

It has been pointed out in connection with Fig. 155, Chapter III, that it is desirable where possible to draw a set of press tools so that the punch shall be directly above the die in elevation, with the plan of the punch above the elevation and the plan of the die below the die elevation. See Fig. 155. But it is often impossible to show the tools in this arrangement without using too small a scale to be desirable. Fig. 425 is a drawing where it is necessary to show the plan of the punch at one side of the elevation in order to make it full size on a convenient size of paper. This set of press tools is for piercing and blanking the piece illustrated by Fig. 426.

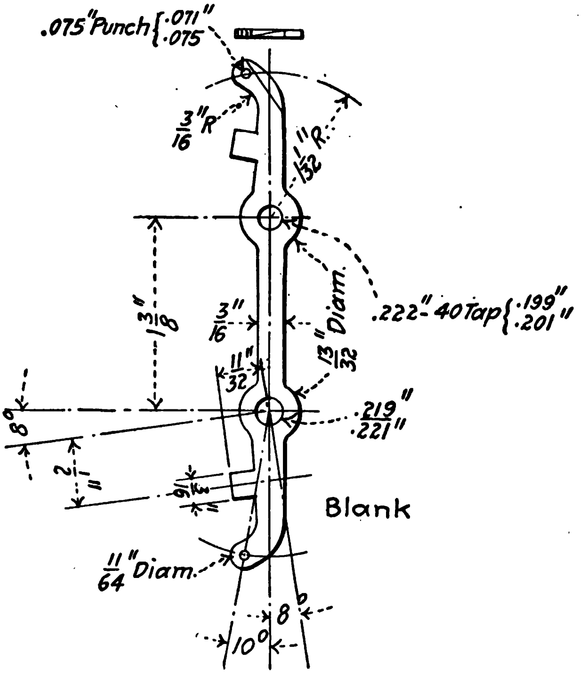


FIG. 426.—Drawing of Blank Produced in Dies shown by Fig. 425.

An interesting feature of this drawing is the material list at the side. Such a list is always of value on a detail drawing and in some drawing rooms it is a regular part of detail sheets. Referring to the material list it will be noticed that the parts are symboled in the first column to correspond to the symbols on the drawing. Thus *A*-5 for example is a dowel pin and is called for on the schedule as $^5/_{16}$ inch by 2 inch drill rod. And the second column shows that two are wanted.

Very few dimensions are given on the die block for the blanking opening as the dimensions are to be taken from the drawing of the piece itself, Fig. 426.

THE PRECISION LAYOUT

In some instances however the die drawing carries a special layout with location of many sizes of holes for the drilling out of the stock in forming the blanking opening. Such layouts are of special service where a milling machine or other machine tool is arranged for carrying the work and for adjusting it accurately under the tool spindle for the various hole locations.

Thus Fig. 427 is a precision layout for the drilling out of the metal in a blanking die for a curved arm. This particular layout is made for operation under the spindle of a Smith Premier precision machine and the position of all holes is given from a point known as the Zero Point.

The longitudinal distances from the zero point are all given directly to stop lines through the holes to be drilled. The distances above the horizontal line through the zero point are designated by the letter *A* and in the table the first column (with *A* at the foot) carries all of the dimensions above the zero line to the hole centers. So the settings of the machine for each hole are given longitudinally and laterally. The table also gives the drill size for each hole.

While precision drilling machines of this type are not available in the majority of tool rooms there are various methods of drilling out such openings with accuracy either on a miller or under some arrangement of vertical spindle and it is a great aid to the die maker to have before him the layout with hole centers given accurately in two directions. The draftsman familiar with the requirements of the tool room can usually be of considerable assistance in preparing such layouts so as to make them readily adaptable to the man who has the actual die work to perform.

TOOL DRAWINGS IN GENERAL

The ordinary special tool drawing is in many shops a single drawing or set of drawings not likely to be used more than once or hardly used after the tools are made except for occasional reference. In such instances it is generally the custom to make the drawing on regular cream or buff detail paper and without tracing it. Sometimes a pencil drawing answers. But it is better to ink in the drawing and draw in the work itself in red lines or by heavy black dotted or dot and dash lines to distinguish the work from the jig or fixture. It will help to keep the drawing legible in spite of general usage in the tool room if it is given a coat of white

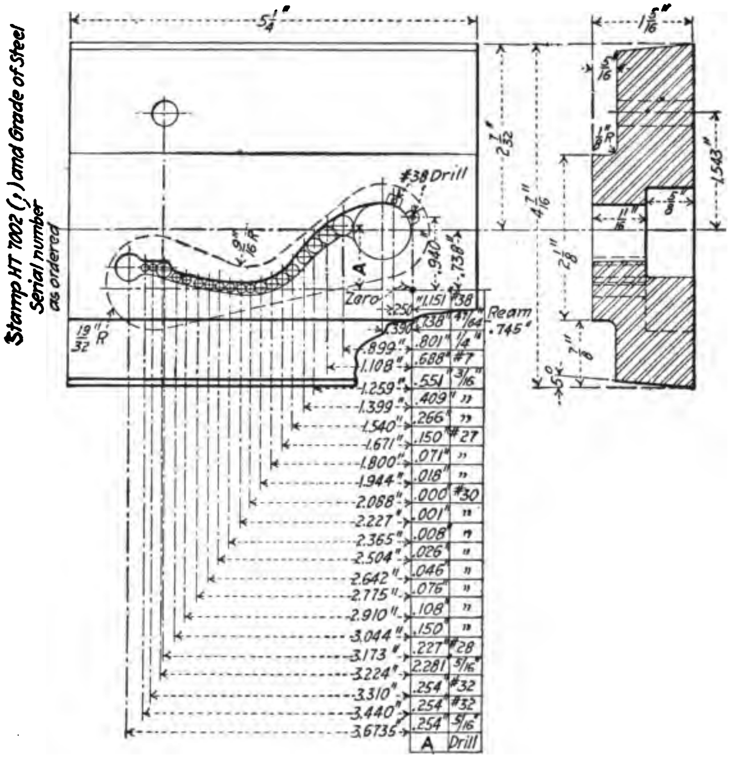


FIG. 427.—Precision Layout for a Die.

shellac. Also it is a good idea to tack the drawing onto a board to prevent it from becoming heavily creased or torn.

In large plants or wherever tool drawings are likely to be used over and over for replacement or duplication of tools they should be traced the same as any working drawing and blue printed.

CHAPTER XII

LIMIT DIMENSIONS ON DRAWINGS

In the manufacture of interchangeable parts the question of limits and tolerance is of greatest importance and as more and more shops are entering into the production of work which is required to be within certain limits of accuracy in respect at least to essential dimensions, it is well for the young draftsman to become acquainted with certain methods followed in establishing high and low limits on drawings.

The bare statement that a shaft is to be say 1 inch diameter means nothing definite unless one is familiar with the requirements and standards of the shop in question. In some places a shaft so dimensioned might be made one or two thousandths under one inch and still be considered sufficiently accurate. And in other shops it might be still farther off from standard size and answer the requirements of the institution. On the other hand in still other places a small fraction of one thousandth of an inch variation in the piece might cause its rejection by the inspector.

Accuracy is a relative term. Absolute accuracy is unattainable at this day in manufacture, but accuracy within exceedingly close limits of error is easily secured and maintained without great difficulty. But an unnecessary degree of refinement is unnecessarily costly and each shop has according to its class of product and its general standards of workmanship a conception of what its own work must measure up to and what limits of variation are to be permitted without violation of the essentials of manufacture in respect to economy of production, facility of assembly, accuracy of operation of the completed mechanism and convenient replacement of parts which may have failed or become worn out in service.

The manufacture of large quantities of interchangeable parts means the use of limit gages. If parts are made in fairly small lots they may still be produced to close limits by the use of micrometers. But whether micrometers or fixed gages are used they must be frequently checked for their own accuracy. And back of the gages or other measuring devices employed, there must be limit dimensions on the drawings.

In a number of the drawings already reproduced in this book there have been various limit dimensions indicated by "plus or minus" so many thousandths; or, as in some instances, the high and low dimensions have both been given in full. Various systems of designating important dimensions have been adopted in different shops and where a suitable system is applied with judgment and carried along with common sense it not only assures the desired degree of accuracy in the particular dimensions specified, but further, it tends to elevate the general character of workmanship on the parts as a whole.

EXPRESSING DIMENSIONS

Writing on this subject of limits on drawings F. H. Bogart has pointed out that the first requirement of an adequate system of expressing dimensions for interchangeable manufacture is to enable the person reading the drawing to distinguish at once whether a dimension is important or unessential. A method that is fast gaining favor is to specify the essential dimensions in thousandths of an inch and the nonessentials in whole numbers and fractions. Thus a shaft 2⅛ inch diameter would be dimensioned 2.125 inch if the dimension were essential and 2⅛ if nonessential. An even dimension like 2 in. becomes 2.000 if it is an essential dimension. The dimension $2^1/_{16}$ in. if expressed as a decimal would be 2.0625 in. Allowing a tolerance of 0.003 in. the dimension could be written in any one of the following ways: 2.0625 in. plus or minus 0.0015 in.; 2.063 in. plus 0.001 in. minus 0.002 in.; or 2.064 in. minus 0.003 in.

Up to quite recent times it was almost universal practice to specify the maximum and minimum dimensions outside of which the measurement must not go, by allowing a definite variation both above and below the absolute dimension. This is usually called the "plus or minus limit" and is expressed by writing the allowed variation in thousandths after the absolute dimension, and prefixing the plus and minus sign. Thus 2.125 in. ± 0.003 in. fixes 2.122 in. and 2.128 in. as the minimum and maximum dimensions respectively, and limits the range of variation on that particular dimension, on every part that may be produced, to some point inside these two figures.

One of the arguments against the use of plus and minus allowances is the ease with which dimensions may be permitted to overlap each other on those sections of parts intended to fit together. For example, the diameter of a driving pin might be dimensioned 0.748 in. plus or minus 0.001 in.; the bushing into which the pin was to be a free fit when the parts were assembled would be dimensioned 0.750 in. with an allowance of 0.001 in. either way. The limiting dimensions in this case would be for the pin, maximum, 0.749 in.; minimum 0.747 in.; for the hole in the bushing, maximum 0.751 in. minimum 0.749 in. It is apparent that, while there would be a clearance of 0.004 in. between the largest hole and the smallest pin, there would be a line and line fit between a pin of maximum diameter and a hole of minimum diameter.

A SIMPLE METHOD

A method which is used to some extent on munitions parts is in its application to diametrical dimensions, very simple. On external diameters the dimension is invariably specified *minus* the allowed tolerance; on internal diameters it is always specified *plus* the tolerance. For example, the diameter of a pin which was later to be assembled in a bushing would be dimensioned 0.748 in. minus 0.001 in.; the hole in the bushing would be dimensioned 0.749 in. plus 0.001 in. The same principle is followed in specifying linear or length dimensions, the distance between surfaces or shoulders between which parts are to be assembled, being dimensioned with a plus allowance; the parts fitting into the space having in every instance a minus allowance.

In Fig. 428 are shown details of three parts used quite generally in automobile design and known as a four bearing ring, bushing and driving pin. The dimensioning of these illustrates not only the method of expressing the dimensions as advocated above but clearly shows how the allowances are specified in the manner just described. It reduces necessary additions and subtractions to a minimum, and shows at a glance the full tolerance between the largest and smallest part that may be produced within the allowed limits. The absolute dimensions specified show the minimum clearance between any finished surface of a part and the surface of another part fitting to it when assembled, as for example between the pin and bushing in Fig. 428.

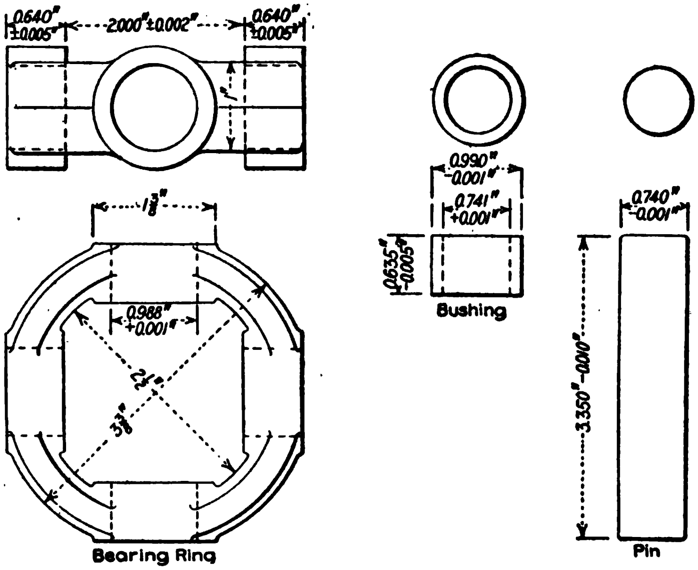


FIG. 428.—A Pin and Bushing.

In some plants that find it necessary to revise their drawings for interchangeable manufacture it may already be drawing room practice to select on every part to be detailed a base line or reference point from which all the principal linear dimensions originate. It has always been recognized as good practice and widely though not universally used. But on drawings giving working tolerances on all essential dimensions, it is necessary to adopt this method exclusively.

A PULLEY EXAMPLE

In Fig. 429 are shown four examples of a conventional three step cone pulley marked *A* to *D* respectively. Example *A* shows this pulley as it would be dimensioned on an old time blue print. Example *B* shows how the same drawing would come out of some drafting rooms if they were set to the task of dimensioning the working drawings of a product for manufacturing to limit gages. Treating the matter as a simple case of changing nominal dimensions for the same sizes, with the allowable error in machining limited, the drafting room erases the old figure on the tracing, rewrites it in decimals, and affixes a tolerance based on its judgment as to what the production department ought to be able to work to, which in the example shown is plus or minus 0.005 in. on each step, and plus or minus 0.010 in. on the overall length. Yet example *B* as dimensioned could not be produced interchangeably, as will be apparent from a moment's analysis. Bearing in mind that without regard to how the piece is machined the shop may take full advantage of every tolerance, assume first that they start from the large end, face off the rim, and then machine, each successive step

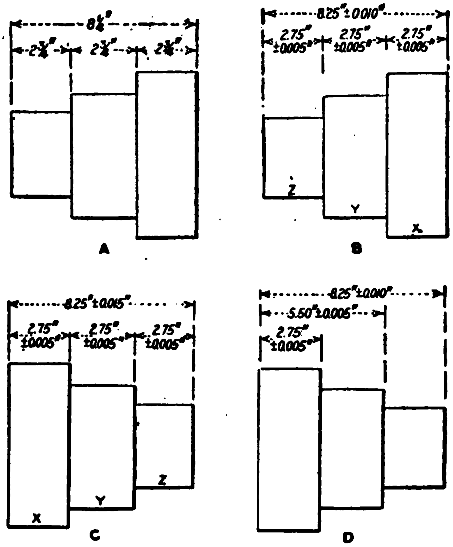


Fig. 429.—Four Methods of Dimensioning.

working toward the small end. If steps *X*, *Y* and *Z* happen to be all to the minimum gage, the overall length will be 0.005 in. under the minimum; if all the steps are to the maximum gage, the total length is 0.005 in. over the maximum. Only by successive steps happening to average up to maximums and minimums could the total come out inside the tolerance granted for the total length, when machined in this manner.

Many manufacturers have already traced out this difficulty, and in an effort to overcome it have made the total tolerance equal the sum of the separate tolerances. Example *C* shows the same drawing revised in this way. Assume now that for their convenience the production department faced off both ends to length as the first operation, and then finished the steps from the small end toward the large. The overall length might be 8.265 in., the first two steps machined might be to the minimum gage, leaving 2.775 in. for the width of step *X*, which is 0.020 in. greater than the maximum limit allowed.

AN IMPORTANT PRINCIPLE

This brings us to the most important principle of tolerance dimensioning: *Never* combine two or more tolerance dimensions to make up a total tolerance dimension, or specify any single dimension in such a way, that it is related to or affected by any other. Adherence to this principle in adopting a dimensioning method for working drawings will save any manufacturer 95 per cent of the trouble he would otherwise have. Had some of the contractors for munitions parts taken the drawings as originally submitted and revised them with this principle in mind, retaining the same nominal dimensions and limits, and had they followed this up with designs of tools and gages based on the same principle, it would have worked magic in the satisfactory production of those parts.

A sketch made for an original print of a fuse component is reproduced at Fig. 430-*A* exactly as it was dimensioned on the print, only the principal dimensions being given. The same part is shown at Fig. 430-*B* dimensioned with the "platform" as the principal reference line for outside dimensions, the face of the base for inside base depths, and the face of the stem for stem end bores. It will be observed from this drawing that sub-

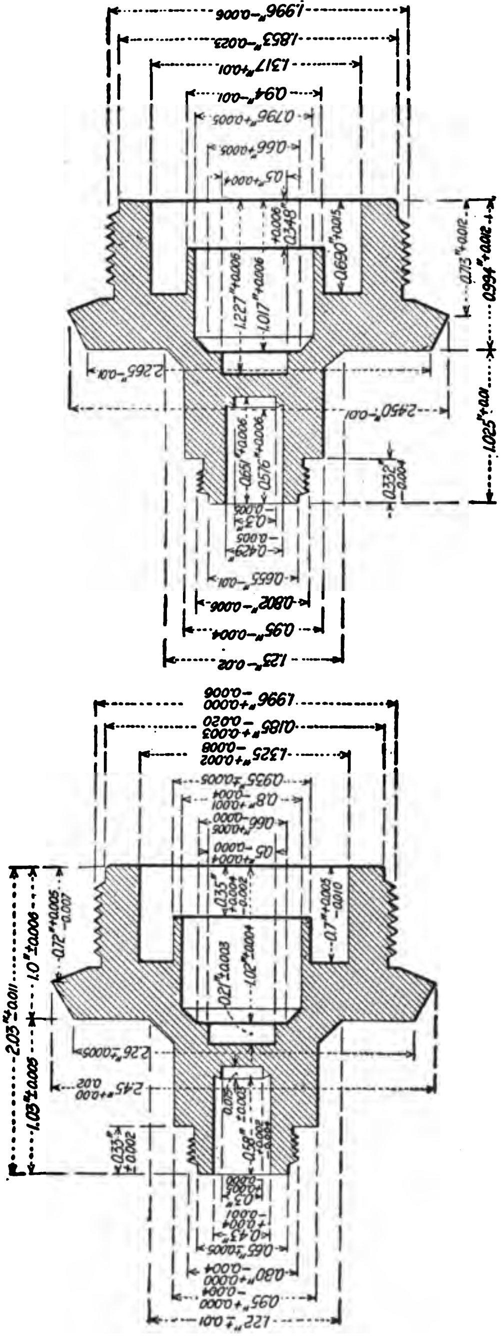
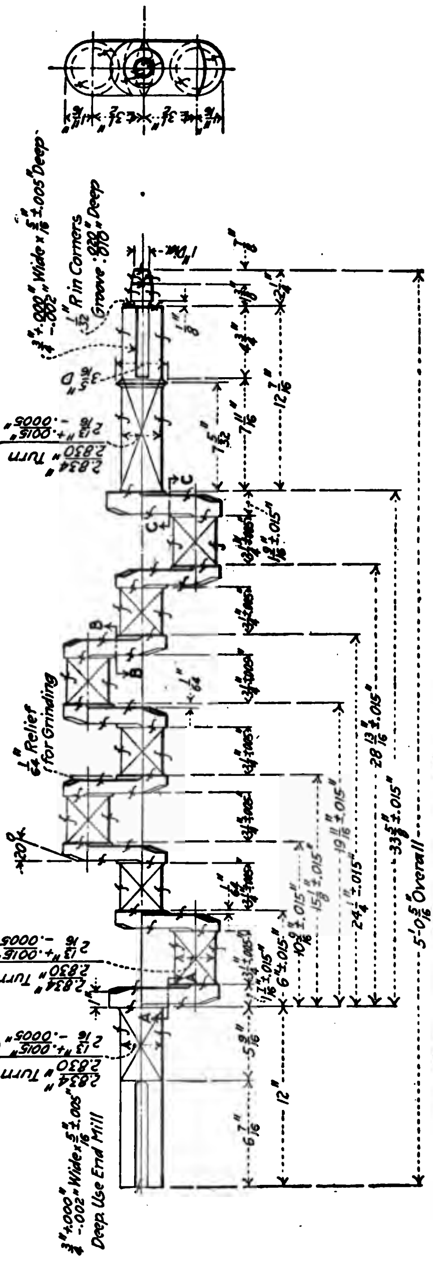


FIG. 430.—Two Methods of Dimensioning a Fuse Part.



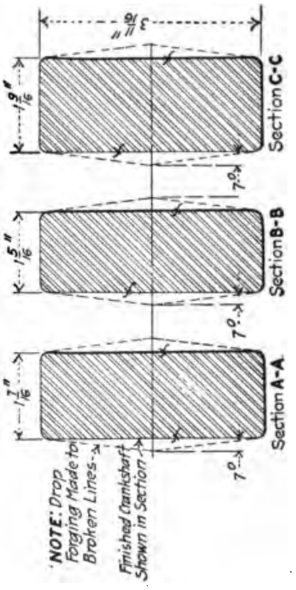

3 11/16"
1 7/16"
1 5/16"
1 9/16"
7°
Section A-A
Section B-B
Section C-C
NOTE: Drop Forging Made to Broken Lines
Finished Crankshaft Shown in Section

FIG. 431.—Crank Shaft Drawing with Limit Dimensions.

reference lines may be established for certain groups of dimensions at will, as long as no linking dimension is interposed between two separate dimensions or groups.

CRANK SHAFT AND PISTON DRAWINGS

Fig. 431 is a crank shaft drawing with limit dimensions. It will be seen that the important linear dimensions are taken

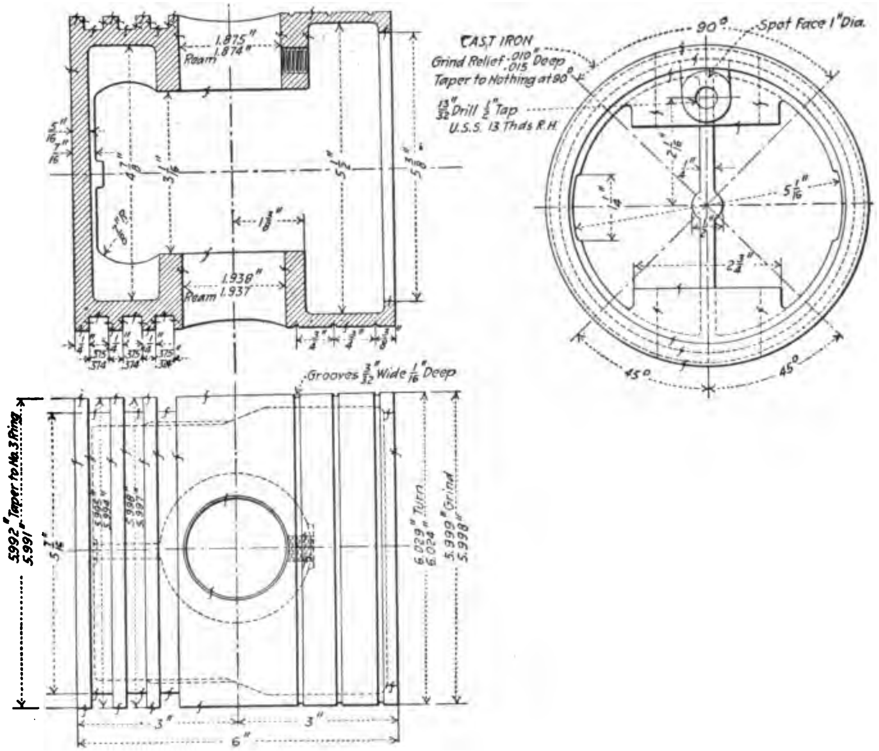


Fig. 432.—Piston Drawing with Limit Dimensions.

from the bearing shoulder at the left end and the length of none of the bearings is affected by the fact that the adjacent bearing may be made to either maximum or minimum dimension.

The piston drawing in Fig. 432 is dimensioned with maximum and minimum diameters for turning and grinding and the widths of the ring grooves are similarly dimensioned with high and low limits. Also the reamed holes for the pin bearings are dimensioned with high and low limits for diameters.

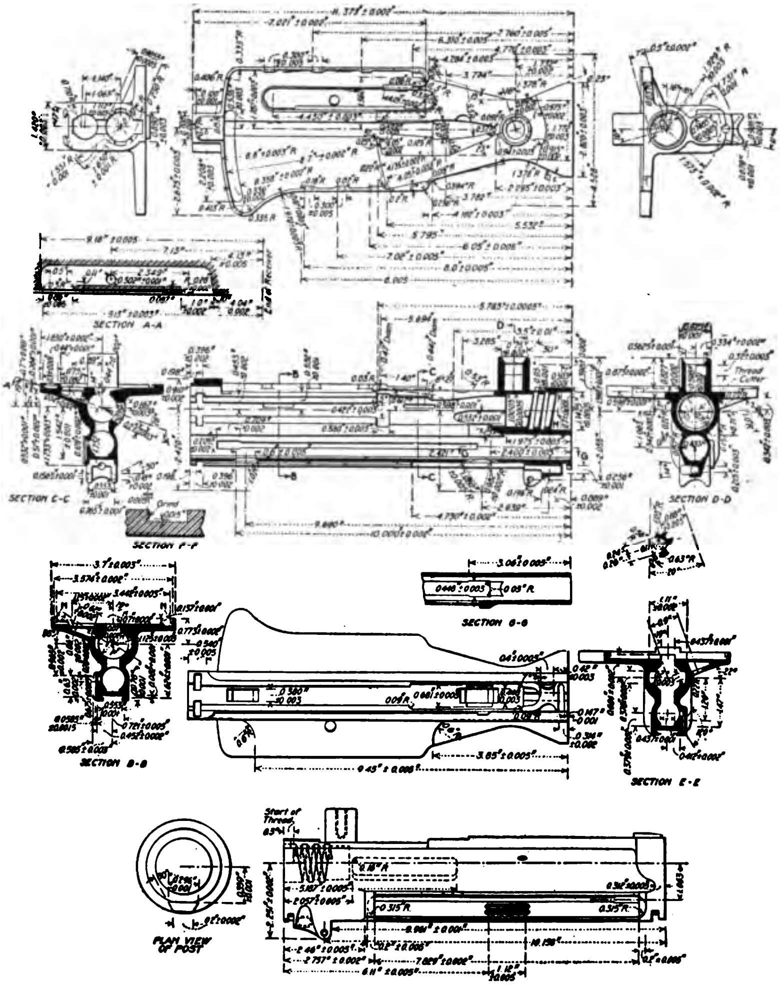


FIG. 433.—Machine Gun Receiver with Limit Dimensions

MACHINE GUN RECEIVER

The drawing of the machine gun receiver in Fig. 433 is a most striking example of a complicated piece of interchangeable manufacture with complete limit dimensions. Note that the linear dimensions are all taken from the common working point at the front end of the receiver.

There are several hundred dimensions on this drawing with plus and minus allowances and the entire drawing is a remarkable piece of work combining many features well worth the careful study of anyone interested in the practice of a modern drafting office and manufacturing plant.

CHAPTER XIII

ISOMETRIC AND OBLIQUE DRAWINGS—SHOP SKETCHES

The isometric drawing is an approximation to a perspective view; and for the reason that it gives in one view the appearance of two or more faces of an object it is occasionally used in the drawing office to illustrate some special piece of work where a picture is wanted rather than a working drawing with two or more views in orthographic projection. Isometric views are often used in patent office drawings. Sometimes the isometric view is used as a working drawing with dimensions placed as with the usual drawing. This practice has not however been extended appreciably in American establishments on regular machine shop work.

One great advantage of familiarity with isometric drawing and with its modification, "oblique" drawing, is found in the consequent capacity for making shop sketches clearly, due to the knowledge of the forms assumed by circles, squares and other figures when thrown into isometric views. The purpose of this chapter is to discuss isometric drawing sufficiently to enable the young draftsman to learn something of the principles under which such "pictures" and sketches as may be necessary may be made to advantage. Not that shop sketches require any special artistic effect; but it is true that usually they are made more quickly and generally more satisfactorily if of the isometric forms; that is in fair approximation to true perspective. For facilitating the making of isometric drawings and sketches, specially ruled isometric paper can be obtained. This has lines at the necessary angles for all parts of the work.

In the first place in order to illustrate the close resemblance between the isometric drawing and a photographic view of an object, Figs. 434, 435 and 436 are shown. Compare the photographic representation of the die block in Fig. 434 with the isometric view of the same block in Fig. 435. Also compare

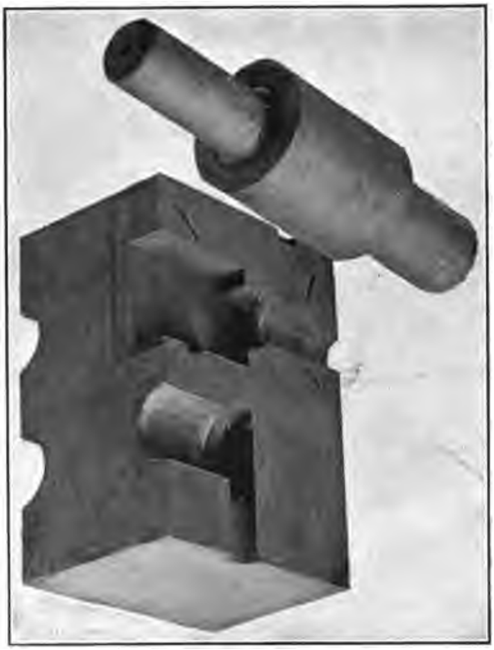


FIG. 434.—Die and Punch for Heading Machine

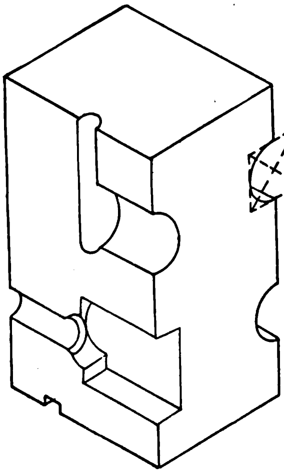


FIG. 435

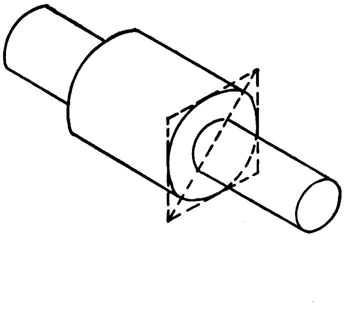


FIG. 436

Isometric Sketches of Die and Punch shown in Photograph, Fig. 434.

the photograph of the punch in the foreground of Fig. 434 with the isometric sketch of the punch in Fig. 436.

With objects of ordinary dimensions or where none of the surfaces have any great length as compared with the other dimensions, the isometric view will give a very satisfactory picture of the complete object.

Referring now to Fig. 437 we have a cube in isometric drawing with the lower edges at angles of 30 degrees to the horizontal or ground line and with the upper face angles meeting at *a* forming corner angles of 120 degrees. The faces of this cube give the common face positions and angles for all kinds of objects drawn in isometric manner. See Figs. 438 and 439.

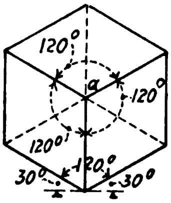


FIG. 437.
Isometric Cube.

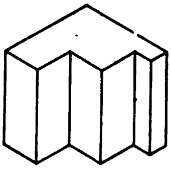


FIG. 438.
Step Block.

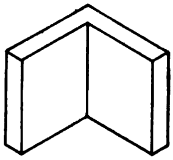


FIG. 439.
Angle Plate.

One of these is the isometric drawing of a step block resting upon its side; the other of an angle plate in similar position.

Fig. 440 shows the construction of the circle in an isometric drawing. The plan of the circle is shown to the left. To draw this in isometric draw first the isometric square. This is the dotted diamond shaped figure at the right. The sides as *a-b* are all of the same length as in the regular square at the left; but the figure contains two 120 degree angles and thus has the diamond form shown, which is of course the same as the top face of the isometric cube in Fig. 437.

The dotted diamond *a, b, c, d,* is the isometric square and the four sides form the construction lines for the isometric circle. This circle is an elliptical figure as represented. The approximate ellipse may be laid out as indicated by the construction lines crossing the isometric square. Thus the lines *a-b* and *b-c* are divided at the center by diagonals from point *d,* and lines *a-d* and *d-c* similarly bisected by oblique lines from point *b.* The intersection of the diagonal lines from opposite points forms the center point from which the short radius *r* is struck for the small end of the ellipse. The corners *b* and *d* form the centers for the long radius *R* for striking the major curves of the ellipse. The construction is so clearly indicated by the diagram, Fig. 440, as to render almost unnecessary any special explanation.

The isometric drawing of the cylinder, Fig. 441, is an application of the foregoing method of drawing the isometric circle. Only here the circle is used to form the top of a cylinder and a second circle is similarly drawn in part to form the visible or front half of the lower end of the cylinder.

Reference to Fig. 442 will show that there are three positions in which the isometric cylinder may be drawn. The vertical position has already been noted in connection with Fig. 441. There are in addition to the vertical position two horizontal positions as in Fig. 443, one with the cylinder extending to the right, the other to the left. The circles in the isometric drawing are naturally identical except that one inclines toward the right and the other to the left.

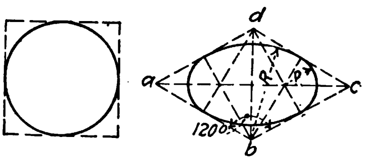


FIG. 440.—The Isometric Circle.

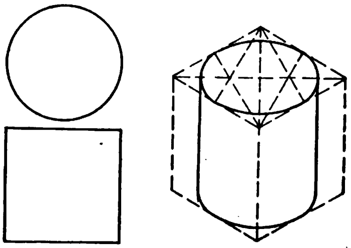


FIG. 441.—Isometric Cylinder.

Figs. 444 and 445 are merely to show the elliptical form of the isometric circle as drawn in as an intersection of a plane with a sphere instead of upon the face of a cube. The purpose of both the cube and spherical sketches in the engraving is to illustrate as clearly as possible the form of the isometric circle in different positions. It is often the case that the circle in isometric drawing is shaped erroneously as say in Fig. 446 where the major axis is vertical.

Figs. 447 and 448 are still other drawings of the isometric circle as forming part of an object in metal or wood. Fig. 447 is a three way joint with circular hubs or bosses and with a hole bored or cored through each. Fig. 448 shows three bosses inside the walls of an angular casting. Note the inclination of the axes of the circles as shown isometrically. Construction

Fig. 442

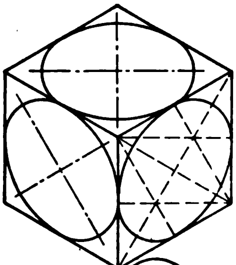


Fig. 444

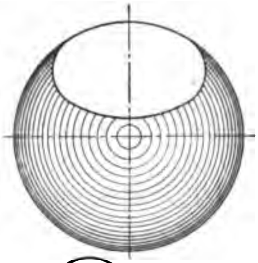
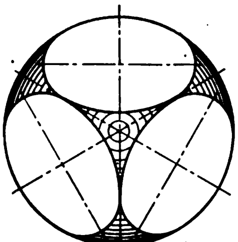


Fig. 445



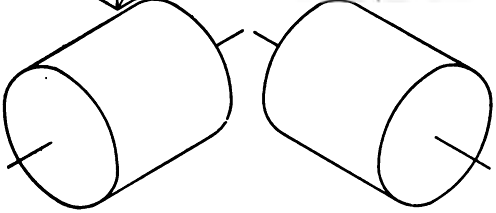


Fig. 443 —Correct Positions.

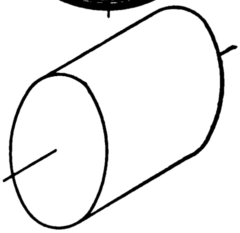


Fig. 446.—Incorrectly Shown.

Isometric Cylinders.

lines are left in some cases to indicate the method of drawing in the ellipse.

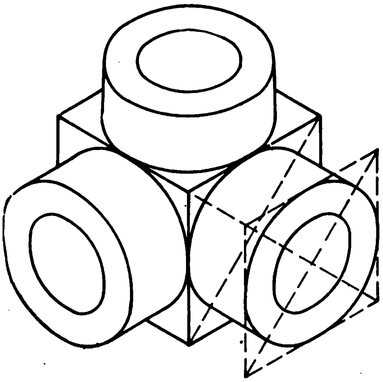


Fig. 447

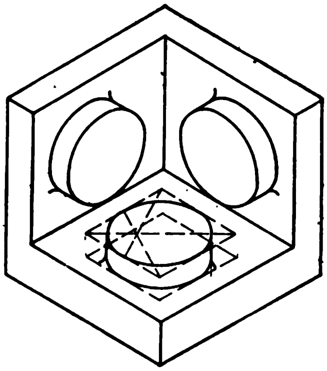


Fig. 448

Three Positions of Circles.

A layout of the circular hole in isometric drawing may be of value here as it is an easy matter to draw this hole in distorted form unless care is taken to place it correctly. In Fig. 447 the various holes in the lugs must obviously be along curves in the same plane as the faces of the bosses themselves. But where several holes are shown located about the face of a single disk for example, it is not always so easy to position there axes as they should be placed. Refer to Figs. 449 and 450. These show a simple disk with a hole bored through the axis. Fig. 449 shows the construction lines; Fig. 450 is the disk without the construction lines. Fig. 451 shows the same disk with three holes correctly drawn for an isometric view. Fig. 452 is another drawing but is incorrect for the holes *B* and *C* should lie along a line parallel to the major axis of hole *A* as in Fig. 451. It is quite often the case that where a number of holes are shown in the face of a job of this kind they will be located along radial lines as in Fig. 452. But this is incorrect practice as will be seen upon study and comparison with Fig. 451.

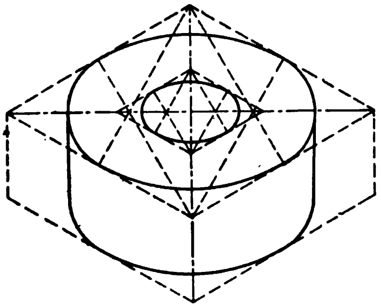


FIG. 449.

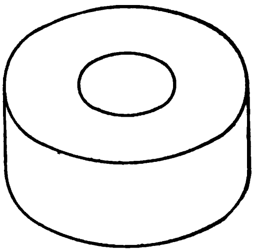


FIG. 450.—Showing Fig. 449 without Construction Lines.

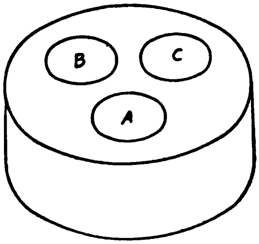


FIG. 451.—Correct Position of Holes *A*, *B*, *C*.

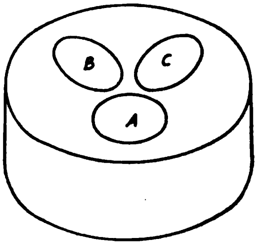


FIG. 452.—Showing Incorrect Positions of Holes *B* and *C*.

The forming tool holder in Fig. 453 is shown as an isometric drawing and the view is left with construction lines for the various round corners. Fig. 454 shows the same holder with a circular forming tool in place. This drawing will form a good example for practice.

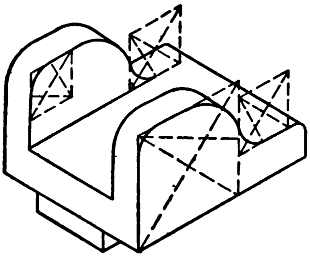


Fig. 453

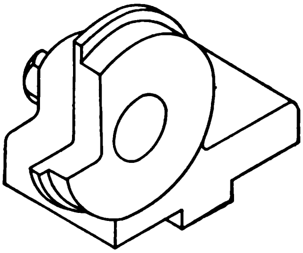


Fig. 454

Forming Tool Holder.

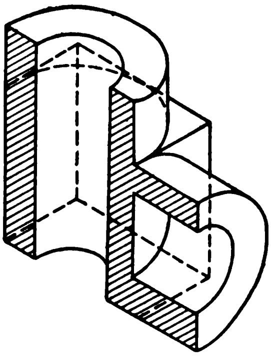


Fig. 455

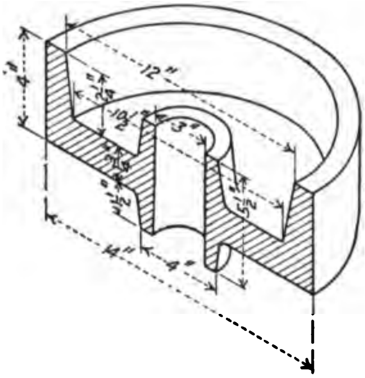


Fig. 456

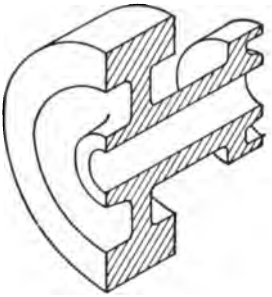


Fig. 457

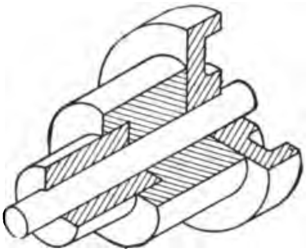


Fig. 458

Isometric Sections.

A number of isometric sections are illustrated in Figs. 455, 456, 457 and 458. These show the possibilities in isometric drawing of bringing out clearly the internal structure as well as the outside appearance of objects. The assembly isometric in Fig. 458 is of especial interest. The use of such drawings is a great convenience at times and they undoubtedly do show many details to greater advantage than is possible with the methods of conventional projection.

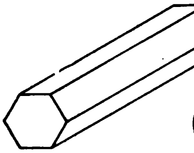


Fig. 459

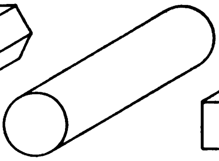


Fig. 460

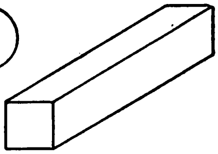


Fig. 461.—Preferred to Fig. 463.

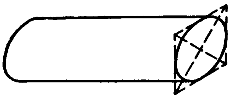


Fig. 462.—Incorrect.

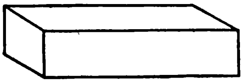


Fig. 463

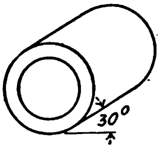


Fig. 464

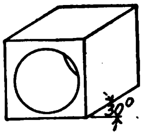


Fig. 465

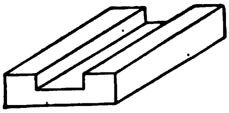


Fig. 468

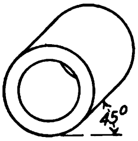


Fig. 466

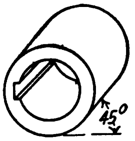


Fig. 467

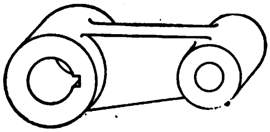


Fig. 469

Oblique Drawings.

OBLIQUE PROJECTION

In oblique projection the object is shown with one face parallel to the vertical plane so that its true shape is seen. Thus Fig. 459 represents an oblique drawing of a hexagonal bar with the true form of the end shown toward the observer. The same is true of the round bar in Fig. 460. The circular form is here drawn as a true circle instead of being elliptical as it would be in an isometric drawing. Fig. 462 illustrates the incorrect method of showing such an object in oblique drawing. Fig. 461 is an oblique drawing of a square bar and this is preferable to Fig. 463 which shows the end distorted because the side of the bar has been placed parallel to the plane.

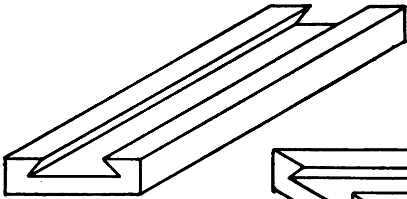


Fig. 470.

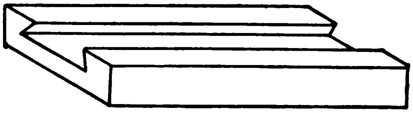


Fig. 471.—Preferable to Fig. 470.

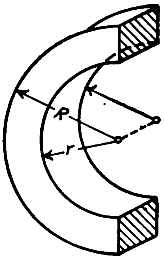


Fig. 472

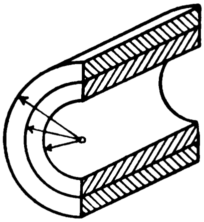


Fig. 473

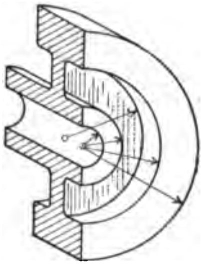


Fig. 474

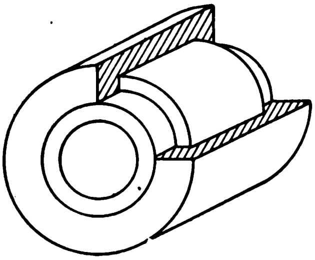


Fig. 475

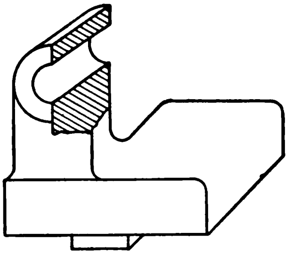


Fig. 476

Sections in Oblique Drawing.

Figs. 464 to 467 are other objects shown by oblique drawings. Some of these drawings are made with the work shown at an angle of 30 degrees, others are at 45 degrees. In all cases the end of the piece is seen in its correct outline and proportions.

While it is desirable in oblique drawings to have the irregular face of an object parallel to the plane of the drawing there are instances where this is not feasible owing to the distortion that may occur when the object is of considerable length as compared to its other dimensions. Thus compare Figs. 470 and 471. It would be an advantage to show the dovetail end of the guide here drawn, parallel to the plane of observation or in the picture plane so called. But if so drawn, the slender proportions of the guide would be still further extended in the view and a very poor idea conveyed of the actual proportions of the casting. However, by placing the view as in Fig. 471 a very satisfactory idea is given of the entire object.

A number of oblique sections are reproduced in Figs. 472 to 476. It is apparent that such views are much easier to make than the isometric sections referred to above, particularly as all circles still remain circles in the oblique drawing.

The method of dimensioning isometric and oblique drawings will be understood from Fig. 456.

Draw external views and sections similar to some of those in the preceding pages and put on all necessary dimensions to make the drawing complete.

SHOP SKETCHES

The ability to sketch machine parts rapidly and with sufficient accuracy to enable them to be of service for reference in making new parts or for making from them complete working drawings is best developed by practical experience in actual sketching of castings and forgings around the shop or if these are of small size by placing them on the table and making free hand drawings to show the essential surfaces and dimensions. A free hand sketch does not require to be in exact proportion to the original and if it is more or less rough and anything but artistic it is still of service if it shows the part distinctly and carries the important dimensions.

It is best to sketch on a pad of cross-section paper or in a loose-leaf note book with cross ruling. Make the sketch before placing dimensions on it. That is, complete the view or views (during which process more or less handling of the work is necessary) then wipe the hands to remove grease and dirt and with scale and pencil measure and note down on the sketch the dimensions required. Do not be afraid of placing too many dimensions on the rough sketch. When it is later referred to the chances are that a number of figures will be missing and another trip to the shop will be required to complete the scaling of the object sketched.

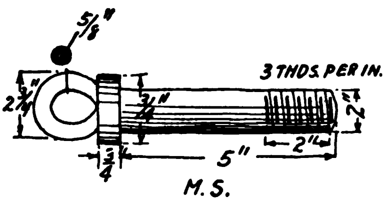


FIG. 477.—Eye Bolt.

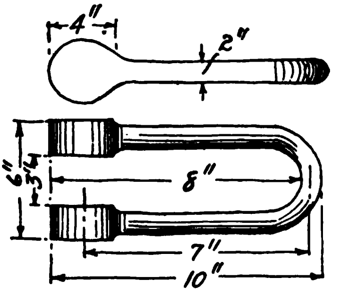


FIG. 478.—U-Forging.

Shop Sketches.

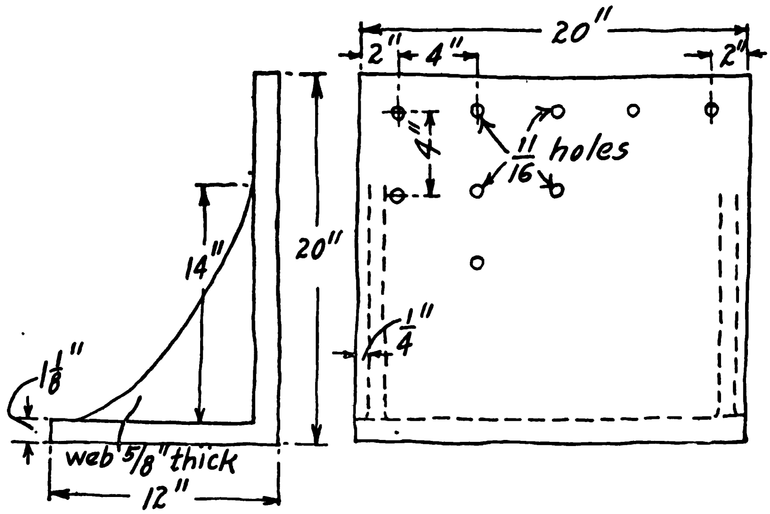


FIG. 479.—Sketch of Angle Iron.

A few typical shop sketches are added here in Figs. 477 to 487. The first two are simple forgings. The figures give all the data required for duplicating in forge shop and machine shop. Fig. 479 is a sketch of an angle iron or knee shown by two views. Another and simpler way to show this is by the oblique sketch, Fig. 480. Fig. 481 is a boring bar holder sketched for reproducing in the shop. Fig. 482 shows one way of representing a die bolster by rough sketch.

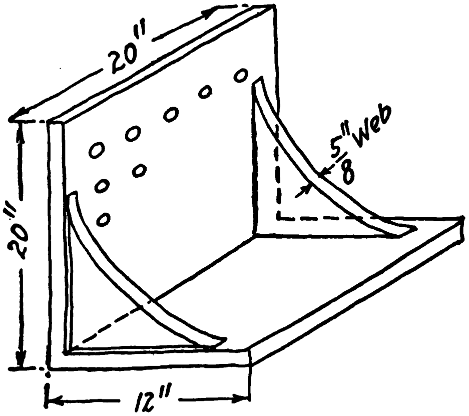
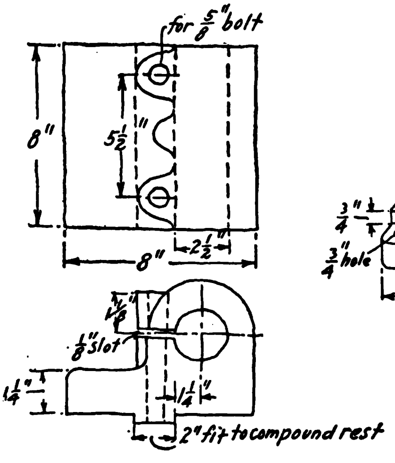


FIG. 480.—Sketch of Angle Iron.



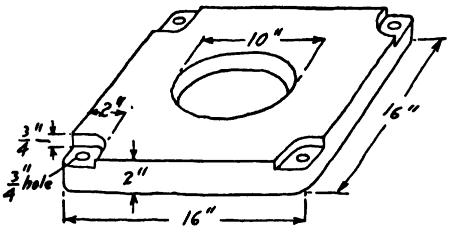


FIG. 481.—Boring Bar Holder. FIG. 482.—Die Bolster.

In Fig. 483 is sketched a V block for a miller table, and the detail of the table itself is also included. The practice of showing on shop sketches a portion of a table or other machine member is important for any attachment to be placed on such a table must be made to suit T-slots or other holding surfaces on the machine. The sketch also shows a section of a cutter to be used on a certain job which is to be handled in the V block.

Fig. 484 is a sketch of a shoe and wedge fixture for a long

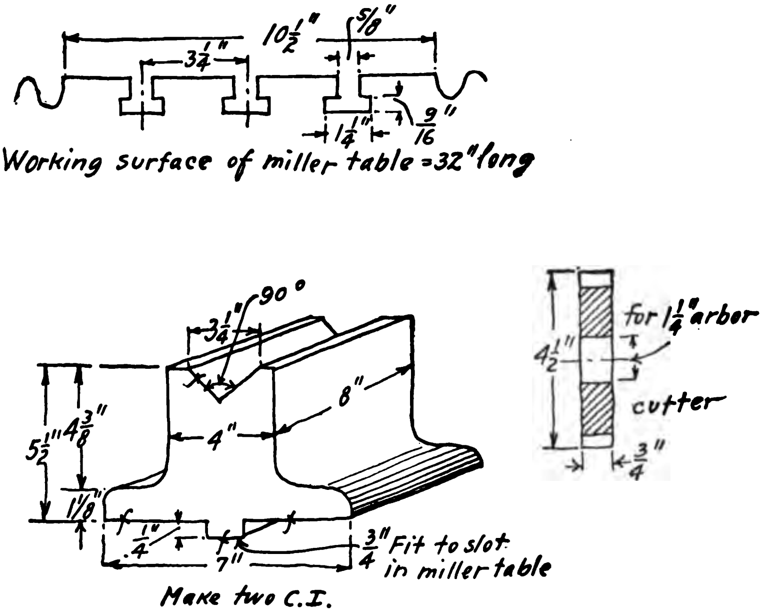


FIG. 483.—V-Block for Miller Table.

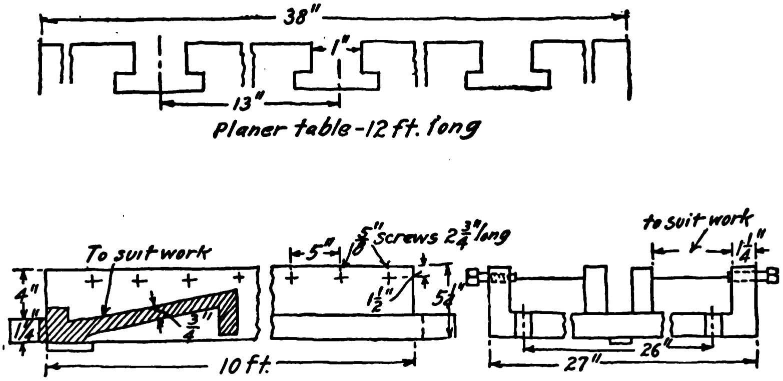


FIG. 484.—Wedge Fixture for Planer.

planer, and here again a detail is included of the planer table to enable the fixture to be drawn up to suit the machine on which it is to be used.

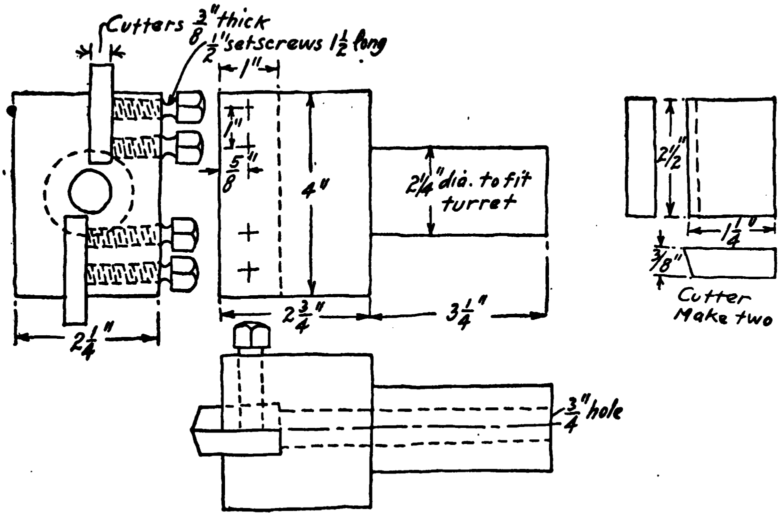


FIG. 485.—Facing Tool for Turret Lathe.

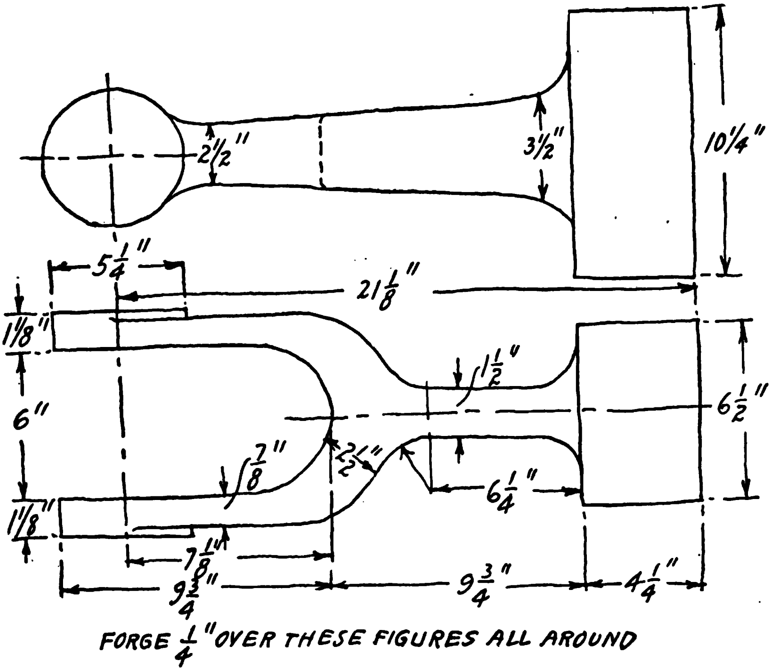


FIG. 486.—Forging for High-speed Engine Connecting Rod.

A turret lathe tool with two facing cutters is shown in the sketch, Fig. 485. Note the inclusion of a detail of the cutter.

Fig. 486 is a sketch of a forging required for a connecting rod. The sizes given are the machine shop figures but the information for the forge shop is contained in the note "Forge ¼ inch over these figures all around."

A connecting rod brass is seen in Fig. 487. This is a combination sketch in that the general view of the brass is an oblique sketch while an additional end view and bottom plan are included to give certain figures not easily carried on the main sketch. Such auxiliary views or sketches are often desirable and should be included wherever they will help to a clear understanding of the work in hand.

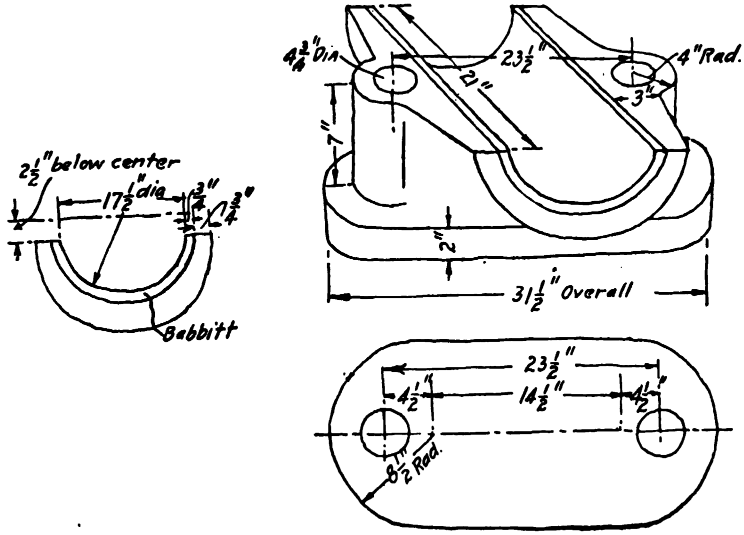


Fig. 487.—Connecting Rod, Brass.

Practice making sketches of such parts as are shown in the foregoing engravings. And sketch freely all sorts of shop parts until the capacity to turn out a practical free hand sketch has been fully developed.

INDEX

A

Air Pump Reamers, Details of, 202, 203
Angle Casting, 187
Angles, Bisecting, 21
Angular Lines, Projection of, 39
Application of Principles of Projection, 54–81
— — T-Square and Triangles, 10, 11
Apron for 25-inch Lathe, Details, 208
— Jig, Lathe, Drawing, 209
Arbors and Shafts, Drawing Various Types, 127
Assembly Drawing of Ball Vise, 146
— — — Cross Slide Tail Stock, 150
— — — Miller Spindle, 147
— — — Oil Feed Cock, 170
— — — Shaft Hanger, 149
— — — Swing Rest, 151
— — — Turret Lathe Head Stock, 152
— — — Valve Mechanism for Gas Motor, 158
— —, Parts and Sections in, 142
— Views, Two Speed Transmission, 144, 145
Auxiliary Views for True Lengths of Line, 43
— — of Cylinder Cut at Angle, 44
— — — Pyramid Cut at Angle, 44
— — — Square Section Cut at Angle, 44

B

Ball Vise, Photographic Views, 146
— —, Section through, 146
Bearing Bracket for Shaft, Drawing of, 160
Bearing Bracket for Shaft, Photographic View, 160
— Cap, Arrangement of Views in Drawing, 30
— —, Photographic Views of, 29
Bearings, Methods of Drawing, 128
Bench Lathe, Cross Slide Foot Stock, 148, 150.
— — Swing Rest, 149, 151
Bevel Gears, Showing on Drawing, 133
Bisecting a Straight Line, 20
— an Angle, 21
Blow Off Valve Parts, 169
Bolt, Nut and Screw Proportions, 119, 120
Bolts and Nuts, Methods of Drawing, 118, 119
—, Nuts and Screws, Application in Service, 119, 120
Boring and Reaming Bars for Apron Work, 210, 211
—, Bar Drawing, 201
— Tool for the Miller, Drawings, 205, 206
Box, Special, Drawing of, 65
—, —, Photographic Views of, 65
— Support, Cap for, Photographic Views, 184
— —, Photographic Views, 184
Brackets, Cast, Photographic View, 185
Briggs Pipe Thread, 121
Bronze Bearing, View of, 57
Bushings, Drawing of, 55
—, Knurled, Methods of Showing, 139
—, Methods of Drawing, 128–130
—, Pins for, 138

Bushings Shown in Section, 46
—, Threaded, 121

C

Cap for Bearing, Arrangement of Views in Drawing, 30
— — —, Drawing and Photographic Views, 163
— — —, Photographic Views of, 29
— — Box Support, Photographic Views, 184
— — Shaft Bearing, 67
— — — Box, Drawing of, 161
— — — —, Photographic View, 161
— Screws, How Shown, 120
Cams, Steel, Drawing of Set, 195
— and Levers, Showing in Drawing, 132
Cast Brackets, 185
Center of Circle, to Find, 21, 22
Check Valve Tools, Drawings of, 204, 205
Circle, Dividing into Equal Parts, 13
—, — with the Protractor, 14, 15
—, Finding the Center, 21, 22
Circles, Full and Dotted, Drawing, 19
— in Contact, Drawing, 19
—, Locating on an Arc, 16
—, Scribing with Compasses, 13
— Spaced Along Straight Line, 15
Coiled Spring, How Shown, 101, 102
Comb for Typewriter, Type Bars, Drawing of, 199
Compasses, Laying off Points with, 11, 12
—, Scribing a Circle, 13
Compressor Valve, Drawing of, 72
— —, Photographic View, 72
Connecting Rod Brasses, Drawing and Photographic View, 165
Conic Sections, 92, 96
Connecting Rod for Gasoline Motor, Drawing of, 167
— — — — —, Photographic View, 166
Connecting Rod for High Speed Engine, Drawing of, 74
— — — — — —, Photographic View, 74
— —, Intersection of Cutting Plane, 96, 98
Contact, Drawing Circles in, 19
Countershaft Box, Drawing of, 68
— —, Photographic View, 68
Couplings, Section through, 131
Crankshaft Drawing with Limit Dimension, 226
Cross Hatching a Slide and Guide, 143
— —, Conventional, 143
— — of Spindle Boxes, 144
— — or Section Lining, 52, 53
Cross Head, Locomotive, Drawing, 174
— — —, Photographic View, 174
Cross Section for Metals, 142, 143
— Slide Foot Stock for Bench Lathe, 148, 150
Curves and Straight Lines, Joining, 17
—, Irregular or French, 5, 6
—, —, Use of, 17, 18
Cutters, Method of Showing, 140
—, Milling, Application of Helix to, 112, 113
Cutting Square Threads, 107–109
Cylinder Cocks, Drawing of, 172
— Cut at Angle, Development of, 87, 88
— for Locomotive, Drawing, 181
— — —, Photographic View, 180
— — Motor, Several Views, 49
— Head for Motor, Views of, 50
Cylinders, Intersections, 89, 90
—, — at Angles, Development of, 91, 92

D

Details of Adjustable Slotter Tool, 201
— — Boring Bar for Piston Rings, 202
— — — Tool for the Miller, 205–207

Details of Check Valve Tools, 204, 205
— — Tools for Air Pump Valves, 202, 203
—, Two Views Required, 30
Development of Cylinder Cut at Angle, 84, 88
— — —, Intersecting at Angles, 91, 92
— — — Meeting at Right Angles, 90
— — Hexagonal Figures, 87
— — Pyramid, 87
— — Square Tube, 85, 86
— — Surfaces, Intersections, 82–98
— — —, Principles, 82, 83
— — Watch Movement, 154, 156
Dies, Methods of Showing on Drawing, 78–80, 214
—, Precision Layout for, 216, 217
Dimensions on Drawings, Limit, 219–229
—, Method of Expressing, 220
—, Simplifying, 196
— Tabulated, 196
Dividers and Compasses, Laying Off Points, 11, 12
Dividing a Circle into Equal Parts, 13
— — — with the Protractor, 14, 15
— — Line into Equal Parts, 12, 13, 20, 21
Double Milling Fixture, Showing Work in Place, 211
Drawing, Assembly of Milling Machine Spindle, 147
— Board, 3
— Instruments and Their Uses, 1–25
— —, Details of Equipment, 3
— —, Grade Desired, 1, 2
— —, Makes of, 2
— —, Typical Set, 2
—, Isometric, 230–237
—, Oblique, 237–239
— of Apron Jig, 209
— — — Tools, 210, 211
— — Bearing Bracket, 160
— — Bench Lathe Foot Stock, 150
Drawing of Bench Lathe Swing Rest, 151
— — Blank Produced in Dies, 215
— — Blow Off Valve Parts, 169
— — Boring Bar, 201, 202
— — Bronze Bearing, 57
— — Bushing, 55
— — Cap for Bearing Box, 163
— — Comb for Typewriter Type Bars, 194
— — Compressor Valve, 72
— — Connecting Rod Brasses, 165
— — — — for Gasoline Motor, 167
— — — — — High Speed Engine, 74
— — Crank Shaft with Limits, 226
— — Counter Shaft Box, 68
— — Cylinder Cocks, 172
— — Drill Jig for Eccentrics, 207
— — Driving Box, 175
— — Fly Wheel, 69
— — Forked Bracket, 164
— — Friction Disk, 60
— — — Hub Plate, 61
— — — Member, 70
— — — Plate, 62
— — Fuse Parts with Limits, 225
— — Gear Pump, 183
— — Hand Lever, 162
— — Head for Gasoline Motor, 168
— — Locomotive Cross Head, 174
— — — Cylinder, 181
— — — Eccentric, 182
— — — Piston, 173
— — — Side Frame, 176
— — — — Rods, 177
— — — Valve and Bushing, 179
— — Machine Gun Receiver, 228
— — Miscellaneous Machine Parts, 76–78
— — Universal Bar for Typewriter, 194
— — Oil Feed Cock, 171
— — Packing Ring, 72
— — Pin and Bushing with Limits, 222
— — Pipe Bracket, 71

Drawing of Planer Tool, 75
— — Pulley with Limit Dimensions, 223
— — Punches and Dies, Method of Showing, 79, 80
— — Punch Dies for Tie Plates, 213
— — Reamer with Tabulated Dimensions, 199
— — Roller, 58
— — Set of Steel Cams, 195
— — Shaft Bearing Cap, 67
— — — Box Cap, 161
— — Shifting Lever, 63
— — Special Box, 65
— — Spring Cap, 59
— — Thrust Collar, 66
— — Truck Wheels, 163
— — Typewriter Bell Crank, 195
— — — Frame, 190–193
— — Valve Head Tool, 73
— Pen, How Used, 7
Driving Box, Locomotive, Drawing, 175
— — — Photographic View, 175

E

Eccentric, Locomotive, 182
Eccentrics, Drill Jig for, 207
Ellipse, How Produced, 93
Expressing Dimension, for Limits, 220

F

Face Plate, Showing Thread, 121
Feed Mechanism for Turret Lathe, 153
First Angle Projection, Occasional Advantage of, 78–81
— and Third Angle Projection, Comparison of, 31
Flat Scales, 5
Fly Wheel, Drawing of, 69
— —, Photographic Views, 69
Forked Bracket, Drawing and Photographic Views, 164
French Curve, Uses of, 17, 18
— Curves, 6
Friction Disk, Drawing of, 60
— —, Photographic Views, 60
— Member, Drawing of, 70
— —, Photographic View, 70
— Plate, Drawing of, 62
— —, Photographic Views, 62
— Hub Plate, Drawing of, 61
— — —, Photographic View, 61
Fuse Parts, Two Methods of Dimensioning, 225

G

Gages, Plug and Ring, Showing on Drawing, 140
Gasoline Motor, Assembly Drawing of Valve Parts, 158
— —, Connecting Rod, 166, 167
— —, Cylinder Head, 168
— —, Cylinders and Valves, 157
— —, Photographic View of, 157
— — Piston, Limits or Drawings, 227
Gear Box with Roller Bearings, 156
— Pump, Drawing of, 183
— — and Jig, Photographic Views, 182
Gears, Showing on Drawing, 132, 133
—, Spur, Laying Out, 133, 134
Geometrical Problems, 19
Glass Box Explanation of Projection, 34–37

H

Hand Lever, Drawing of, 162
— —, Photographic View, 162
— Wheels and Handles Showing on Drawing, 135, 136
Hanger, Shaft, Assembly Drawing, 148, 149
Head for Gasoline Motor, Drawing and Photographic View, 168
Heavy Shaft Box, Photographic View, 186
Helix and Its Application, 99–115
— Advance, Lead, Pitch, and Angle, 99–101
—, Application to Milling Cutters, 112, 113

Helix, Application to Taper Reamers, 114, 115
—, — — Worm Threads, 111, 112
—, Applied in Drawing Square Threads, 105
—, — — — V-Threads, 104
—, — to Screw Threads, 99
—, Comparison of Different Pitches, 100
Helical Grove, for Cam, 108
Hexagon Head Screws, How Shown, 120
—, to Construct, 21, 22
Hexagonal Objects, Development, 87
Hidden or Dotted Section, 135, 137
Hyperbola, How Produced, 94, 96

I

Intersection, Development of Surfaces, 82–98
— of Cylinders, 89, 90
— — Flat Plane with Side of Connecting Rod, 96, 97
— — Machine Handle with Hub, 97
— — — Parts, 96–98
— — Round Boss or Collar, 97
— — — Lug on Sleeve, 97
Involute Gear Tooth, Laying Out, 134
Irregular Curve, 5, 6
— —, Use of, 17, 18
Ink for Drawing, 6
Isometric and Oblique Drawings, 230–238
— Circles, 233–235
— Cube, 232
— Cylinder, 232, 234
— Drawing, Examples of, 232–238
— — of Tool Holder, 236
— —, Principles of, 230–233
— Location of Holes, 234–236
— Sections, 236, 237
— Sketch of Die and Punch, 231

J

Jig Plate, Showing Holes and Bosses, 16
Jigs for Eccentrics, 207, 208
Joints, Pinned, 138

K

Keys, Showing in Place, 126
Key Ways and Slots, Showing on Drawing, 124–126
Knurled Bushings, Methods of Showing, 139

L

Laying Off Points with Dividers, 11, 12
— Out Spur Gears, 133, 134
Lettering, 24, 25
Lever, Shifting, Drawing of, 63
—, —, Photographic Views of, 63
Levers and Cams, Methods of Showing on Drawing, 132
Limit Dimensions, Methods of Expressing, 220
— — on Drawings, 219–229
— —, Fuse Parts, 225
— —, an Important Principle, 224, 225
— —, on Pin and Bushing, 222
— — on Pulley Drawings, 223
Limits on Machine Gun Drawings, 228
— on Piston Drawings, 227
Line, Bisecting, 20, 21
—, Erecting Perpendicular to, 20, 21
—, True Length of, 40, 42
Lines and Circles, Exercises in, 18, 19
— Used on Drawings, Full Line, Dotted Line, Dot and Dash, etc., 24
Locomotive Cross Head, Drawing, 174
— — —, Photographic View, 173
— Cylinder, Drawing, 181
— —, Photographic View, 180
— Driving Box, Drawing and Photographic View, 175
— Eccentric, Drawing and Table, 182
— Piston, Drawing of, 173

Locomotive Piston, Photographic View, 172
— Side Rods, Drawing-of, 177
— — Frame, Drawing, 176
— Valve and Bushing, Drawing, 179

M

Machine Gun, Receiver Drawing with Limits, 228
— Parts, Intersection of, 96–98
— —, Miscellaneous, Drawings of, 76–78
— Screws, Types of Heads, 121
— Tap with Table of Sizes, 200
Metals, Cross Sections for, 143
Milling Cutters, Method of Showing, 140
— Fixture, Details of, 212, 214
— —, Showing Work in Place, 211
— Machine Spindle, Photographic Views, 147
— — —, Sectional Drawing, 147

N

Nuts and Bolts, Methods of Drawing, 119
—, Knurled, Methods of Showing, 139
—, Square Thread, 106, 107

O

Oblique Drawings, 237–239
— —, Examples of, 237
Oil Feed Cocks, Drawing, 171
— — —, Photographic Views, 170
Oilstone Used for Sharpening Pens, 7

P

Packing Ring, Drawing of, 72
— —, Photographic View, 72
Parabola, How Produced, 94, 95
Parts and Sections in Assembly Drawings, 142–158
Pen, Ruling, 7
—, —, How Used, 7
Pencils, Flat and Round Points, 6
—, Grades and Hardness, 6
Photographic Views of Angle Casting, 187
— — — Bearing Brackets, 160
— — — — Cap, 29
— — — Blow Off Valve Parts, 169
— — — Hollow Shaft, 29
— — — Boring Bar, 202
— — — Box Support, 184
— — — Bronze Bearing, 57
— — — Bushing, 55
— — — Cap for Bearing Box, 163
— — — — — Box Support, 184
— — — Cast Brackets, 185
— — — Check Valve Tools, 204
— — — Compressor Valve, 72
— — — Connecting Rod Brasses, 165
— — — — — for Gasoline Motor, 166
— — — — — High Speed Engine, 74
— — — Countershaft Box, 68
— — — Driving Box, 175
— — — Fly Wheel, 69
— — — Forked Bracket, 164
— — — Friction Disk, 60
— — — — Hub Plate, 61
— — — — Member, 70
— — — — Plate, 62
— — — Gas Engine Cylinder Head, 50
— — — Gear Pump and Jig, 182
— — — Hand Lever, 162
— — — Head for Gasoline Motor, 168
— — — Locomotive Cross Head, 173
— — — — Cylinder, 180
— — — — Piston, 172
— — — — Valve Bushing, 178
— — — Oil Feed Cock, 170
— — — Packing Ring, 72
— — — Pipe Bracket, 71
— — — Planer Tool, 75
— — — Rocker Arm, 28, 29, 187
— — — Roller, 58
— — — Shaft Bearing Cap, 67
— — — — Box Cap, 161

Photographic Views of Shifting Lever, 63
— — — Special Box, 65
— — — Spring Cap, 59
— — — Steam Pipe Elbow, 188
— — — Surface Plate, 186
— — — Thrust Collar, 66
— — — Truck Wheels, 163
— — — Two Speed Transmission, 145
— — — Typewriter Frame, 189
— — — Universal Ball Vise, 146
— — — Valve Head Tool, 73
— — — Wall Bearing for Shaft, 188
Pinned Joints, 138
Pins for Bushings, 138
Pipe Bracket, Drawing of, 71
— —, Photographic Views, 71
Piston Drawing with Limits, 227
— for Locomotive, Drawing, 173
— — —, Photographic View, 172
— Valve and Bushing for Locomotive, 179
Pitch of Helix, Comparison of Angles, 100, 101
— — —, Defined, 100, 101
Planes of Projection, 31
Planer Tool, Drawing of, 75
— —, Photographic View, 75
Plug and Ring Gages, Showing on Drawing, 140
Precision Layout for Dies, 216, 217
Problems in Simple Construction, 17
Projection, Application of Principles, 54–81
—, Different Arrangement of Views, 26
—. Explanation of Views in, 26, 27
—, First Angle, 32
—, — and Third Angle, Comparison of, 31
—. Isometric, 232–238
—, Oblique, 237–239
— of a Steel Square, 38, 39
— — Angular Lines, 39
— — Bushings, 46
Projection, Orthographic, as Used on Drawings, 26–53
—, the Planes of, 31
—, Third Angle, 33
—, Transparent Box Explanation, 34–37
—, Use of Sections in, 45
Protractor, Use in Dividing Circle, 14, 15
—, Various Kinds, 5
Pulleys, Section through, 131
Pump, Gear, Drawing of, 183
—, —, Photographic View, 182
Punch and Die for Typewriter Parts, 214
— — —, Various Methods of Drawing, 79, 80
— Dies for Tie Plates, Details of, 213
Pyramid, Development of, 87

Q

Quadruple Square Thread, 108
Quality of Instruments, 2
— — Paper, 7

R

Reamer and Tap, 198
— Drawing with Table of Dimensions, 199
Reamers for Air Pump Valves, 202, 203
—, with Spiral Teeth, 114, 115
Rocker Arm, 187
— —, Photographic Views, 28, 29
Roller with Long Hub, Drawing of, 58
Ruling Pen, How Used, 7

S

Scale, Division of, 4
—, Triangular and Flat, 4, 5
Screw Heads, Showing on Drawing, 137
Screws, Nuts and Bolts, Proportion of, 119, 120
Screw Threads, Application of Helix, 103–110

Screw Threads, Examples of Drawing with Helix, 104
— — in Their Conventional Form, 116–122
Scribing Circles with Compasses, 13
Sectional Views of Machine Parts, 65–72
Section Lining or Cross Hatching, 52
— of Pulley Hub, 126
— — Spindle, 126
— through Spindle and Bearings, 47
Sections, and Detail Parts, 123–141
—, Hidden or Dotted, How Shown, 135, 137
— in Assembly Drawings, 142–158
— — Oblique Drawing, 238
— of the Cone, 92–96
— — Turret Lathe Head, 152
—, Showing Bushings, 46
— through Bearings and Bushings, 128
— — Pulleys and Couplings, 131
— — Rolls, 127
—, Use of in Projection, 45
Set Screws, Cup Point, Flat, Round, etc., 120
Shade Lines, Use of, 49, 50
Shaft and Arbor, Methods of Draining, 127
— Bearing Cap, Drawing of, 67
— — —, Photographic Views of, 67
— —, Wall, 188
— Box Cap, Drawing of, 161
— — —, Photographic View, 161
— —, Heavy, 186
— Hanger, Assembly Drawing, 148, 149
Shafts, Showing Keys in Place, 126
—, Spindles, Showing on Drawing, 123, 124
Sharp V-Thread, Proportion of, 116
Sheet Metal Parts for Typewriter, 191
Shop Sketches, 239–244
— —, Angle Iron, 240, 241
— —, Boring Bar, 241
Shop Sketches, Connecting Rod Brass, 244
— —, Die Bolster, 241
— —, Eye Bolt, 240
— —, Facing Tool, 243
— —, Forging for Connecting Rod, 243
— —, V-Forging, 240
— —, V-Block, 242
— —, Wedge Fixture for Planer, 242
Shop Sketching, Methods, 239
Showing Detail Parts and Sections, 123–141
Side Frame, Locomotive, Drawing, 176
— Rods, Locomotive, Drawing of, 177
Simplifying Dimensions, 196
Slots and Key-ways, Showing on Drawings, 124–126
Slotter Tool, Details of, 201
Spindle Nose, Threaded, 121
—, Taper Hole in, How Drawn, 126
Spiral Milling Cutters, 112, 113
Spring Cap, Drawing of, 59
— —, Photographic View of, 59
—, Coiled, How Drawn, 101, 102
Spur Gears, Laying Out, 133, 134
— —, Showing on Drawing, 132
Square Head Bolts, How Shown, 120
— Stock for Springs, 102
— Thread Cutting, Effect of High Tool, 109
— — Nuts, Methods of Showing, 106, 107
— Threads, Application of the Helix, 105
— —, Cutting, 107–109
— —, Double Thread, 106
— —, Single Thread, 105
Steam Pipe Elbow, 188
Steel Cams, Drawing of Set, 195
— Square, Projection of, 39
Straight Line, to Bisect, 20
— Lines and Curves, Joining, 17
Studs, Methods of Showing, 119
Surfaces, Development of, 82-98